









# ANNUAL REPORT OF THE PROGRESS OF CHEMISTRY,

And the Allied Sciences,

PHYSICS, MINERALOGY, AND GEOLOGY;

*Including the applications of Chemistry to Pharmacy, Medicine, Agriculture,  
the Arts and Manufactures:*

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## ADVERTISEMENT.

SINCE the publication of the last volume of the "Annual Report," Mr. De La Rue, whose great experience in all the departments of Chemistry added much to the correctness of the English Edition, has been prevented by many occupations from continuing the work he began. He has, however, kindly consented to continue his valuable assistance in the province of Chemistry applied to the Arts and Manufactures.

The present Editors have used every exertion to prevent the present Volume from being in any respect inferior to those which have preceded it, and they have endeavoured to make it an accurate representation of a work which will be found to contain the latest and most perfect Report of the Progress of Chemistry both in England and abroad.



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## NOTICE FOR THE TABLES.

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Tab. A. Analyses of soils, to face p. 460.

Tab. B to G. Analyses of ashes, to face p. 460.

Tab. H. Analyses of guano and other manures, to face p. 460.

Tab. I, K and L. Analyses of food and fodders, to face p. 471.

Tab. M. and N. Analyses of food and fodders, to face p. 497.

Tab. O and P. Analyses and properties of coal, to face p. 497.

Table on the distribution of the elements in nature, to face p. 554.

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## ERRATA.

Vol. II, p. 525, read :

$$\begin{aligned} n^0 \text{ C.} &= \frac{2}{3} n^0 \text{ R.} &= \frac{2}{3} n^0 + 32^0 \text{ F.} \\ n^0 \text{ R.} &= \frac{3}{4} n^0 \text{ C.} &= \frac{3}{4} n^0 + 32^0 \text{ F.} \\ n^0 \text{ F.} &= \frac{5}{9} (n^0 - 32^0 \text{ C.}) &= \frac{5}{9} (n^0 - 32^0) \text{ R.} \end{aligned}$$



# PHYSICS

AND

# PHYSICAL CHEMISTRY.

**Generalities. Mean Value of Periodic Functions determined by Observation.**—A large proportion of the most important natural phenomena, such as the daily and annual variations of temperature and atmospheric pressure, the variations of the terrestrial magnetic force, &c., have a periodic course; and as in almost all these cases it is desirable to know the mean value of the respective magnitudes for a given period, it is important to know the smallest number of observations and their distribution during the period, by which the determination of the mean value appears to be ensured. Lloyd(1) has replied to this question as follows. Every periodic function may be expressed by the series :

Generalities.  
Mean  
value of  
periodic  
functions  
determined by  
observation.

$$u = a_0 + a_1 \sin (v + a_1) + a_2 \sin (2v + a_2) + a_3 \sin (3v + a_3) + \dots$$

in which  $a_0$  or the true mean

$$a_0 = \frac{1}{2\pi} \int_{-\pi}^{+\pi} dv \cdot u$$

Assuming  $u_1, u_2, u_3, \dots u_n$  as the values of the function which correspond to the values of the variables

$$v, v + \frac{2\pi}{n}, v + 2 \frac{2\pi}{n}, \dots v + (n-1) \frac{2\pi}{n}$$

it may be shown that the arithmetical mean of these values for every value of  $v$  is

$$a_0 + a_n \sin (n v + a_n) + a_{2n} \sin (2 n v + a_{2n}) + \dots$$

(1) Instit. 1849, 56; Report on the 18th Meeting of the British Association. Notices and Abstracts, 1.

General-  
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Mean  
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But as the series assumed as a basis is always convergent, we approximately obtain, if  $n$  be sufficiently large,

$$a_0 = \frac{1}{n} (u_1 + u_2 + u_3 + \dots u_n).$$

The error thus committed approaches the nearer to  $a$ , the greater the value of  $n$  is.

The mean value is therefore determined with sufficient accuracy by two equidistant observations, if  $a_2$  be a magnitude which may be neglected; this for instance is the case in the daily course of temperature, which almost follows the simple law of the sines, and is therefore represented by two terms of the series above given. In all other magnetic and meteorological functions  $a_3$  is small; therefore three equidistant observations suffice for the determination of the mean value. As the choice of these three periods is perfectly optional, they may be so distributed as to obtain at the same time approximately the highest and lowest values of the function, or in other words, the amplitude of the periodic oscillation.—This, for example, is the case when we observe the magnetic declination, if observations are taken at 6 o'clock in the morning, at 2 P.M., and 10 P.M., at which periods we also obtain the maxima and minima of the temperature, and of the tension of vapour, as well as the greatest atmospheric pressure. If we add the hours 10 A.M. and 6 P.M. we also obtain the maxima and minima of the other magnetic elements.

If the entire periodic course of the function has been determined previously by a more extensive series of observations, the observations may be made at optional instead of equidistant intervals; these will then always be selected in reference to the observation of the greatest and smallest values.

**Central Observatory for Physical Sciences.**—Kupffer(1), in a letter to Arago, communicates the fact of a central observatory for physical purposes being established at St. Petersburg. It is destined for the purpose of providing the necessary localities and apparatus for all the more important physical investigations, such as the determination of the coefficients of elasticity, expansion, refraction, &c. It is intended to serve as the centre of all the magnetic and meteorological stations of the Russian empire, at which the instruments are compared and rectified, and the observations compared, computed, and arranged; finally, it is to serve as a school for observers and physicists, and for scientific undertakings of every description.

**Molecular Actions. Capillarity.**—The mutual attraction of material particles of a fluid being exerted equally in every direction

(1) Compt. Rend. XXIX, 267.

is no impediment to the mutual displacement of a fluid. It is only at the surface of fluid bodies where the uniform attraction in all directions necessarily ceases, that a diminished mobility of the particles, a certain cohesion vertically to the surface, and consequently in the case of flection, a resistance or tension, such as is experienced in bending a spring, is observed.

Molecu-  
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It is well known that the phenomena of capillary attraction have been connected with this state of tension at the surface; accordingly the value of the forces of traction which a line (*e. g.* of one millimeter in length) at the surface of a fluid has to sustain on both sides, and the curvature of the surface being given, the determination of the capillary effects of the fluid may be considered as a mere matter of calculation.

Although this theoretical deduction of the capillary phenomena entirely corresponds with experimental results, as far as capillary tubes are concerned, the same cannot be asserted of other capillary phenomena. Carefully conducted researches on these points, therefore, continue to afford considerable scientific interest.

Measurements of the elevation of water in capillary tubes at the ordinary temperature, have uniformly led to the value  $H = 15.1$ , the millimeter being taken as unit. It means the height to which water ascends in a tube of 1<sup>mm</sup> in semidiameter. The same number is also proportional to the surface-tension of water, and if taken as the surface-unit(1), and multiplied by the length-unit, namely 1<sup>mm</sup>, the cubic contents of a body of water is obtained, which may be borne by a section of the water-surface of 2<sup>mm</sup> in breadth, without displacing it.

Several years ago, Hagen(2) published a treatise, in which he attempted to deduce the above-mentioned constant  $H$  from the elevation which water attains in rising between flat plates. He gave the preference to this mode of experimenting to that of employing capillary tubes, as he found that it was less easy to determine the elevation of the surface in the latter with the same accuracy as in the former; and also because it is difficult to ascertain the exact dimensions of the bores of the tubes. The values which he thus determined for distilled water and well-water at 10°, vary from  $H = 11$ , to  $H = 15.272$ (3); they do not therefore justify the preference which he maintained in favour of his mode of proceeding. Indeed comparative experiments of his own with capillary tubes(4) exhibit a much

(1) See Annual Report for 1847 and 1848, Vol. I, 4.

(2) Pogg. Ann. LXVII, 24.

(3) Hagen adopts the Parisian line as the unit in his calculations. Therefore, in order to render a comparison possible between his data and those of other physicists, which we communicated in our last Annual Report, it is necessary to multiply his number with  $\left(\frac{1000}{443.296}\right)^2$ .

(4) Pogg. Ann. LXVII, 165.



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actions.  
Capilla-  
rity.

greater accordance among themselves as well as with the results obtained by other observers.

The discrepancies that we have quoted could not depend upon errors of observation. Hagen attributes them to a gradual alteration in the tension of the liquid surface, owing to the relative freshness of the water. In order clearly to determine this point, he has gone through a new series of measurements on the elevation of water between parallel plates(1), taking care to allow the fluid to stand some hours previously. He thought he had observed, though not invariably, that the surface thus assumed a more uniform tension. The results of these new experiments actually exhibit a much greater concordance. They gave 9.41 as a mean value of  $H$ .

If the tension of the surface of the water, in the capillary tubes, experiences similar alterations, which, if Hagen's view be correct, must be assumed, then in a tube of a radius of 1<sup>mm</sup> the water would after a few hours descend from its first point of elevation 15.1<sup>mm</sup>, to 9.4<sup>mm</sup>. This is not, however, the case, according to the experiments hitherto instituted in tubes well cleansed with potassa and previously moistened with spirits of wine.

In using alcohol and olive-oil, which are well-known to adhere more strongly than water to glass, Hagen observed no such alterations in the tension of the surface. The elevations of the two last-named liquids between parallel plates, as determined by Hagen, also correspond very satisfactorily with the values calculated from the elevations in capillary tubes (according to the experiments of Frankenheim and Brunner).

Hagen has deduced the constant magnitude  $H$ , or a corresponding proportional value, from several other capillary phenomena, viz.: from the elevation of water on the sides of a plate immersed vertically(2); from the weight of drops falling off(3); and from the force necessary to maintain moistened discs floating on the liquid, while in contact with it(4). The values thus found by him are considerably less than those calculated from the capillary elevation proper. Hagen considers that this is sufficiently accounted for by the rapid loss of freshness of the surface, owing to standing. He would, however, have given a much higher value to his investigations, if he had succeeded in discovering the true cause of this variability, and in deducing therefrom the results of his experiments.

We mentioned in the last Annual Report (Vol. I, p. 5), that Frankenheim has employed his observations on the elevation of liquids in capillary tubes, for the purpose of calculating the weight and height

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(1) Pogg. Ann. LXXVII, 449.

(2) Pogg. Ann. LXVII, 28.

(3) Pogg. Ann. LXVII, 106; LXXVII, 455.

(4) Pogg. Ann. LXXVII, 457.

of the liquid layer which is found between the moistened disc and the liquid surface at the moment the former is torn from the latter. He bases his calculations upon a formula given by Poisson. In answer to our remark, that it would have been better not to have neglected the second term of the formula, Frankenheim(1) has replied that he considered the suspended layer as independent of the influence of the meniscus. In this case his proceeding is justified; but it must then be remembered that the numbers he has calculated can have no other meaning but that of limiting values. They must not be looked upon as the true, or even approximate, expressions for the force of cohesion.

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actions.  
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rity.

Hagen has illustrated more closely a very remarkable destructive influence, which capillarity exerts upon the *vis viva* of water(2). If two circular jets of water, of the same diameter and equal velocity, meet in the direction of their axes, it is well known that they form a circular, continuous, mirror-like disc, which is perpendicular to their common axes. Savart's observations(3) prove that if the velocity be trifling, and the thickness of the jets considerable, the radius of the disc may amount to half the height of the pressure-column. Generally, however, it is even below the fourth part of the pressure-column. The direction taken by the drops that fall off all round, proves distinctly that the *vis viva* possessed by the water whilst in the jets, is to a considerable extent destroyed at the edge of the disc. Hagen has proved, in a most convincing manner, that this rapid diminution and destruction of *vis viva* does not depend upon the collision of the jets, but upon the *capillarity* or tension of the surface.

If a wire be held into the disc, the threads of water are divided, and do not reunite, a segment being formed, the curvature of which increases towards the circumference. It appears as if the external threads of water were drawn towards the continuous part of the disc by a lateral force. This force operates visibly, even in opposition to the weight of the water.

If a piece of metal, provided with a slit, be held into the disc, the portion of water that penetrates through the opening remains separated from the rest of the disc, and is projected radially, much beyond the circumference of the disc. If the metallic plate is inserted immediately above the axis of the jet, the thread of water isolated by the slit is propelled almost to the height of the pressure-column. The velocity of the water is therefore not destroyed by the concussion, but remains unaltered where the influence of surface-tension, upon which the formation of the disc depends, is obviated.

Hagen explains the force of surface-tension, which retards the

(1) Pogg. Ann. LXXVII, 445; LXXVIII, 578.

(2) Pogg. Ann. LXXVIII, 451.

(3) Ann. Ch. Phys. 1833, LV.

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actions.  
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rity.

motion, in the following manner: if we consider the two surfaces of the water-disc as composed of concentric rings, each ring, in following the movement from within, will run from the circumference of the coincident jets, to the edge of the disc; and as the ring must dilate proportionately, its tension must be constantly overcome, which cannot be effected without a loss of power. The tension of such a ring, in the direction of the arch, gives rise to a pressure in a radial direction, which counteracts and retards the movement of the water.

Based upon this assumption, Hagen has calculated the sum of the resistances on both surfaces of the disc. With the assistance of the equation at which he arrives, and of the experiments of Savart, he then determines the magnitude of the surface-tension for the length-unit; or rather, the constant term which is proportional to it, and which we have above designated as  $H$ . He found  $H = 15.486$  (the millimeter being taken as unit), very nearly the same number which has been found for the elevation of water in capillary tubes.

Hagen has also determined, by calculation, the thickness of the moveable water-disc, and he has proved that it is always least at the centre of the radius. At this point, the height of pressure being 1.05 meters, and the bore of the spout 3 millimeters, it only amounts to the 3.4th part of a millimeter. With a pressure of 1.5 meters, the water was dispersed at the circumference of the disc, consequently the cohesion at the surface no longer entirely sufficed to exhaust the *vis viva*.

**Endosmosis.**—The correctness of the law of endosmotic equivalents, discovered by Jolly(1), which we reported last year, has been disputed by C. Ludwig(2). For the present we must doubt the correctness of his conclusions, although they are based upon a large number of experiments. It is not the number of experiments, but the care with which they are performed, which excites confidence. We are of opinion that Ludwig ought, at least in a part of his experiments, to have adhered closely to the simple method selected by Jolly; for by this means alone he would have been capable of ascertaining any deficiencies in the method, or errors in its execution, and of tracing them to their source. Ludwig has neglected this first duty of a careful experimenter, in a most important point. Jolly determined the gradual alterations in the saline solution by weighing, and continued each experiment until all the salt had passed through the membrane into the external fluid. By this means, he avoided the necessity of a chemical analysis of the residue, and he thus clearly avoided all errors of observation connected with the operation. Ludwig, on the other hand, in each case interrupted the experiment

(1) Annual Report for 1847 and 1848, Vol. I, 13; Pogg. Ann. LXXVIII, 261.

(2) Henle und Pfeufer's Zeitschrift für Rationelle Medicin, VIII, Heft 1; Pogg. Ann. LXXXIII, 307 (in abstr.).

before the composition of the external and internal fluid had become the same, and therefore every time required at least one chemical analysis: it is evident from the small amount of solid matter he had to deal with, and from the difficulty of determining the quantity absorbed by the bladder, that considerable errors of observation were thus necessarily introduced.

In fact, the numerical results, although apparently resting on the same bases, agree so little, that Ludwig finds it necessary to assume that the quantity of water passing over to the saline solution depends not only upon the temperature, but also upon the concentration of the solution (curiously enough in an opposite sense with regard to chloride of sodium and Glauber's salt), and even upon the age of the bladder.

The same treatise contains some remarkable observations on the capability of animal bladder to absorb saline solutions, from which it follows that the capacity of the membrane for saturation, when placed in the middle of the solution, is lower than the concentration of the latter. Thus in a solution of common salt of 10 per cent, the membrane absorbed a fluid containing only 7 per cent. The fluid that was again squeezed out of the bladder as far as possible, by the application of very considerable force, contained 10 per cent; it follows that what remained in the bladder can have been little else than water.

It is to be desired, that in continuing his experiments, Ludwig will pay attention to the time consumed, as possibly the membrane might nevertheless gradually have become entirely saturated with the solution. The fact of chloride of sodium crystallizing out of a saturated solution, under the influence of a bladder that has been introduced, which he has also observed, is satisfactorily explained by the first action; it merely proves that the animal membrane at first chiefly absorbs water. This, however, is an old established fact.

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**Atomology. Various Conditions of Matter.**—Brame(1) believes that he has discovered a condition of matter which has not as yet been remarked, and to which he applies the term *utricular state*. He states that the precipitate of the vapour of sulphur is first fluid, or almost fluid; and that it can continue a long time in this condition: that it then forms globules, which are invested by a species of membrane, and represent the utricular condition. He obtains similar results with phosphorus, selenium, iodine, camphor, and other volatile substances. We are unable to enter more fully into the detailed subdivisions, and numerous new names, which Brame proposes for the various forms of the utricular state.

Crystal-  
lization.

**Crystallization.** — Daubrée(1) has succeeded in crystallizing binoxide of tin, titanite and silicic acids. If the vapour of bichloride of tin and water are brought together in a red-hot porcelain tube, small crystals are deposited on the walls of the latter; rather larger ones are obtained by passing in the vapour of chloride of tin, diffused in a stream of carbonic acid, by which it is more finely divided. The crystals of binoxide of tin thus obtained are colourless; they possess the lustre of the diamond, scratch glass, and have a sp. gr. 6.72. They do not appertain to the square prismatic, but to the rhombic system, and exhibit the crystalline shape and striae of brookite. Bichloride of titanium and steam, in the same manner, yield small excrescences of titanite acid, presenting microscopic projections, which appear to possess the crystalline form of brookite. The influence of aqueous vapour upon terchloride, or terfluoride of silicium, in a light-red-hot earthen retort, or in a crucible of the same material, several times gave a deposit of silica, which exhibited a conchoidal fracture, and on the nodulated surface of which a few very small triangular crystalline planes were visible here and there. In all these cases the crystals were not deposited on the red-hot part of the tube or retort, but outside the furnace, on surfaces which were not above 300°.

**Crystallography.**—The investigations of Bravais(2) as to the manner in which material points may be symmetrically disposed in space, and the application of these theoretical considerations to crystallography, will not admit of a short abstract; the same remark applies to the observations of Seguin(3) on the law by which material molecules are maintained at a distance from one another.

Leeson(4) has continued the crystallographic investigations which we have adverted to in the Report of 1847 and 1848 (Vol. I, p. 18); he has pointed out several errors which he thinks are frequently committed in the investigation of crystals. This continuation likewise scarcely admits of condensation.

Chapman(5) has proposed a new method of designating crystalline planes. He considers simplicity, brevity and the capability of being verbally expressed, as the essential conditions of a good system of nomenclature. The latter quality, in our opinion, is of no great importance, inasmuch as in a verbal description, one is more likely to employ the names than the abbreviated symbols of the crystalline planes, which in fact have no connection with one another. Chapman's terminology does not, however, fulfil one

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(1) Compt. Rend. XXIX, 227; Instit. 1849, 292; Ann. Min. [4] XVI, 129; Report of Dufrénoy, Compt. Rend. XXX, 383; Instit. 1850, 115.

(2) Instit. 1849, 91, 117, 180, 198, 228, 386; Compt. Rend. XXIX, 143. Cauchy's Report, Compt. Rend. XXIX, 133; Instit. 1849, 274.

(3) Compt. Rend. XXVIII, 97; XXIX, 425.

(4) Chem. Soc. Qu. J. II, 148.

(5) Phil. Mag. [3] XXXV, 321.

condition which is of considerable importance, viz. that the meaning of the terms should be deducible from the terms themselves, so as to assist the memory. In designating the planes on the figures of crystals, it is very immaterial what designation is employed, as the figure itself affords a clue to their meaning; but when it is necessary to indicate a crystalline form without a figure, the utility of a system of terms for the individual planes may be tested. It is the advantage of several systems of terms proposed in Germany, that the terms convey their own meaning. Chapman's proposal partakes of the disadvantages of many other proposals, that different letters are chosen for different forms, so as to offer no point of assistance, if the memory fail, by which to determine whether A designates the rhombic dodecahedron, or some other form. We have placed the proposals of Chapman for the Regular system of crystals, and the formulæ of Naumann side by side:

Chapman:	P	A	$\frac{1}{m}A$	O	$\frac{1}{m}O$	mO	mOn
Naumann:	$\infty 0 \infty$	$\infty O$	$\infty On$	O	mOm	mO	mOn

In the square prismatic system, Chapman represents OP by P;  $\infty P \infty$  by M;  $\infty P$  by D, &c.; it seems unnecessary to give a more complete synopsis of his terms, as they are not likely to be employed without an explanatory key(1).

**Relation between Composition and Crystalline Form.**—G. Rose(2) has investigated more closely the crystalline form, cleavage and twin-formation of the metals that crystallize in rhombohedrons. He discovered that bismuth, which has hitherto been erroneously supposed to crystallize in the Regular system, is one of them. What has hitherto been looked upon as a hexahedron in bismuth, proves to be a rhombohedron R with terminal edges of  $87^{\circ} 40'$ . The planes of cleavage which are easily produced in this form, and which have hitherto been considered as belonging to the octohedron

(1) The following key to Mr. Chapman's notation may not be unacceptable to the English reader:

PRISMATIC PLANES.		PYRAMIDAL PLANES.	
Monaxial P; M; L.			
Diaxial	D, $D\frac{1}{m}$ , Dm; B, $B\frac{1}{m}$ , Bm.	A, $\frac{1}{m}$ A, mA; E, $\frac{1}{m}$ E, mE; I, $\frac{1}{m}$ I, mI; AA, EE.	
Triaxial	T . . . . .	O, $\frac{1}{m}$ O, mO; U, $\frac{1}{m}$ U, mU; OO; W.	
Tetralxial	. . . . .	Y, $\frac{1}{m}$ Y, mY.	

Prismatic forms are denoted by consonants, pyramidal by vowels. The latter comprise all closed forms, omitting the cube, and all inclined summit-planes with the exception of the basal planes of the oblique systems.—EDS.

(2) Berl. Acad. Ber. 1849, 137; Pogg. Ann. LXXVII, 143; J. Pr. Chem. XLIX, 158; Jahrb. Miner. 1849, 566; Instit. 1849, 342.

Relation  
between  
composition  
and  
crystal-  
line form.

are of two kinds(1), according to 0 R (the more perfect) and according to  $-2$  R (the rather less perfect); less distinct cleavage also takes place according to  $-\frac{1}{2}$  R. Twin-formation, which is produced by the conjunction of two rhombohedrons with  $-\frac{1}{2}$  R, causes the projecting angles of the bismuth-crystals. The terminal edges of the principal rhombohedron are according to Rose :

For Osmium	84° 52'	For Antimony	87° 55'
„ Iridium	84° 52'	„ Bismuth	87° 40'
„ Arsenic	85° 4'	„ Palladium	doubtful
„ Tellurium	86° 57'		

Rose points out the correspondence in regard to form which these metals present with several oxides  $R_2O_3$ , and he also shows that antimony and bismuth are isomorphous not only in the isolated state, but also in analogous combinations (antimony-glance and bismuth-glance).

G. Rose(2) has also pointed out a remarkable analogy of form between certain combinations of oxygen and sulphur. He calls to mind that  $Cu_2S$  and  $AgS$  are isodimorphous, and that the former appears, moreover, isomorphous with  $PbS$ , inasmuch as in fahl-ore (Grey copper, Weissgültigerz)  $PbS$ ,  $Cu_2S$ , and  $AgS$  occur together in variable relations, and as 1 atom of  $Cu_2S$  is combined with 2 atoms of  $PbS$  in cuproplumbite without altering the form or cleavage of galena. Assuming that  $Cu_2S$  is as well able to replace  $PbS$  as  $AgS$ , bournonite may be viewed as a simple sulpho-salt  $Cu_2S$ , 2  $PbS$  +  $SbS_3$ , in which case it possesses a composition analogous to that of the dark Red-silver-ore (Rothgültigerz), 3  $AgS$  +  $SbS_3$ . The form of Red-silver-ore nearly corresponds to that of calcareous spar, that of bournonite differs from it, but presents a great similarity to that of arragonite, which has been hitherto overlooked.

G. Rose(3) has recently examined into the question whether sulphur and arsenic are to be considered as isomorphous elements; a question which had lately been answered in the affirmative by Breithaupt(4), Frankenheim(5) and Kobell(6). This affirmation is partly based upon the fact, that these inquirers have followed Berzelius in assuming the atomic weight of arsenic at only half of that which has been adopted in the Annual Report. We will put the formulæ

(1) Faraday observed during his investigations into the crystalline polarity of bismuth (Phil. Mag. [3] XXXIV, 75; Pogg. Ann. LXXVI, 144), that one of the four planes of bismuth is more brilliant and perfect than the other. The same has been noticed by Haidinger, who proved that native bismuth crystallized in rhombohedrons. (Wien. Acad. Ber. 5. Heft, 150.)

(2) Pogg. Ann. LXXVI, 291; Berl. Acad. Ber. 1849, 13; J. Pr. Chem. XLIX, 155; Instit. 1849, 199.

(3) Pogg. Ann. LXXVI, 75; Jahrb. Miner. 1849, 205; Instit. 1849, 166.

(4) J. Pr. Chem. IV, 237.

(5) System der Krystalle, 28.

(6) J. Pr. Chem. XXXIII, 405.

written according to the former assumption into square brackets, *e. g.* thus: smaltine (Speiskobalt) =  $\text{Co As} = [\text{Co As}_2]$ .

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In the first place, Rose observes that sulphur and arsenic are not isomorphous in the isolated condition, as the former crystallizes in the rhombic or monoclinometric, the latter in the rhombohedral system; arsenic is probably dimorphous, but even the crystals of the second variety are not likely to belong to one of the crystalline systems of sulphur, but rather to the Regular system, if formed at a high temperature. When arsenical nickel or arsenical cobalt is heated in a flask, a black sublimate is first formed and then under this a grey, strongly lustrous crystalline sublimate which under the microscope presents the appearance of hexahedrons with truncated corners. The following combinations have been quoted in support of the adoption of isomorphism: radiated iron-pyrites  $\text{FeS}_2$ , and mispickel  $[\text{FeS}_2 + \text{FeAs}_2]$  exhibit accordance of form in general, of cleavage and of twin-formation; but the angles of the corresponding forms differ more from one another than is generally the case with regard to bodies that are really isomorphous; the chief argument against their isomorphism is the circumstance that there are no intermediate combinations between  $\text{FeS}_2$  and  $[\text{FeS}_2 + \text{FeAs}_2]$ . Mispickel, even if expressed by the formula  $[\text{FeAs}_2]$  can still less be considered isomorphous to the last two substances, as the corresponding angles differ still more, and as also the cleavage is different. The similarity in the crystalline forms of iron-pyrites  $\text{FeS}_2$ , of cobalt-glance  $[\text{CoS}_2 + \text{CoAs}]$ , and smaltine  $[\text{CoAs}_2]$  does not prove isomorphism, inasmuch as these forms appertain to the Regular system of crystallization; the objection to isomorphism is the same here, namely, that cobalt-glance exhibits an entirely different cleavage from the other two minerals; and that smaltine does not present pyritohedral planes, as we observe in the two other minerals, but the planes of a tetrakis-hexahedron. The isomorphism of sulphur and arsenic cannot therefore be proved from the occurrence of the same crystallographic properties in combinations of the two elements which are composed in an analogous manner. Nor is it probable from the capability of a mutual substitution of arsenic and sulphur in the same mineral. Rose is of opinion that the analyses from which this was inferred, *e. g.* of nickel-glance from Schladming and of amoibite from Steben, were not instituted with the pure minerals, but with mixtures. He concludes that we are not as yet justified in assuming arsenic and sulphur to be isomorphous. He finally observes, that the members of the general formula  $[\text{RS}_2 + \text{RAS}_2]$  occur in two different crystalline forms, as proved by mispickel and cobalt-glance, but he doubts that monoclinometric forms appertain to this formula, and more especially to the composition of mispickel. Breithaupt(1) had obtained a



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mineral from the St. Gotthard and Ehrenfriedersdorf composed like mispickel, which he believed to crystallize in the monoclinometric system, and termed *Plinian*; Rose, upon the basis of his own and Breithaupt's measurements, looks upon this mineral as mispickel, which has become distorted, and is imperfectly crystallized.

Laurent(1) has published his views on the relations existing between chemical composition and crystalline form; we extract the following passages in order to elucidate the sense in which certain terms, which have long been employed in Germany in a totally different sense, are now used by several French inquirers.—*Isodimorphism* (a term hitherto(2) used to designate such substances which are both dimorphous, but isomorphous in both modifications, as for instance  $\text{SbO}_3$  and  $\text{AsO}_3$ ) is employed by Laurent and Pasteur to indicate the property of a substance to crystallize in two forms which closely resemble each other, but appertain to different systems.—*Paramorphism* indicates that bodies of a similar constitution (*e. g.* the naphthalin-compounds  $\text{C}_{20}\text{H}_8$ ,  $\text{Cl}_4$ ;  $\text{C}_{20}\text{H}_7\text{Cl}$ ,  $\text{Cl}_4$ ;  $\text{C}_{20}\text{H}_5\text{Br}_3$ ,  $\text{Br}_4$ ) crystallize in different systems, but so that the position and inclination of the planes in the different forms closely resemble one another.—*Hemimorphism* (which has hitherto been employed(3) to designate the case of a crystal being bounded at the two ends of the principal axis by planes of different forms) now means that bodies which possess a similar chemical composition, or a certain analogy of composition, crystallize in forms (of the same or different systems), in which several of the angles are almost identical, whilst others vary considerably. In a tungstate of potassa, and in a tungstate of soda with a different amount of water of crystallization, two-thirds of the angles are stated to be nearly the same, the other angles vary very considerably. Naphthalin-compounds, belonging to the type  $\text{C}_{20}\text{H}_8$  and to the type  $\text{C}_{20}\text{H}_8\text{Cl}_4$  are also said to present hemimorphism among one another.(4) Laurent(5) has also again dwelt upon the term *isomeromorphism* which he has formerly advocated; this takes place, when in two compounds the same number of the

(1) Laur. u. Gerh. Compt. Rend. 1849, 269.

(2) Gmelin's Handb. d. Chemie. 4. Aufl. I, 94 (1843).

(3) Naumann's Lehrb. der Krystallographie II, 194 (1830).

(4) Laurent does not state how many or how few angles of the forms of the various compounds must be approximately equal, or very unequal, or how far the term *d'une certaine analogie dans leur composition* may be extended for different combinations. We could scarcely reproach him with inconsistency, if in following the above theory, he were to adopt Hermann's formulæ for the epidotes (Ann. Report for 1847 and 1848, Vol. II, 403) and quote them in support of his views on hemimorphism (when in the case adduced, not two, but three-thirds of the angles correspond). Laurent, however, expresses himself very strongly against these formulæ in the treatise which we have quoted.

(5) Laur. u. Gerh. Compt. Rend. 1849, 308.

same atoms are arranged in the same proportions in the same form ; but certain atoms of the one compound being found, when compared with the other compound, to have changed places. Several of the compounds cited by Laurent may be looked upon as isomorpho-metameric, *e. g.* the *bichlorhydrate de cinchonine bibromée* and the *bibromhydrate de cinchonine bichlorée*, which may also be quoted as an example of isomeromorphism.

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Nicklès has published an extensive treatise under the title of "Crystallographic Investigations," based upon these views. Even at an earlier period, he imagined(1) that he had discovered remarkable resemblances in the form of compounds, which possess a certain analogy in their composition ; his new investigations(2) occasionally give rise to the impression that the author wished to show ironically how it is possible, with a careless neglect of the bases upon which inquiries of this nature rest (the knowledge of the composition and of the crystallographic properties), to discover apparent regularities. The following example will serve to show what regard Nicklès pays to chemical composition in these investigations : in the first instance(3) he quotes a propionate of copper, as containing as much water of crystallization as the crystallized acetate or butyrate of copper ; and although the former is said to crystallize in a different system from the latter, yet paramorphism is stated to take place. Subsequently(4), propionate of copper is again described, analyses are communicated which are said to lead to the formula  $\text{CuO}, \text{C}_6 \text{H}_5 \text{O}_3 + \text{H}_2\text{O}$ , (according to the notation adopted in the Annual Report), and a calculation is adduced which is supposed to tally well with the analyses and the above formula, in which we merely meet with the assumption that in water 8 parts by weight of oxygen are combined with 0.5 of hydrogen. The author afterwards(5) corrects himself, and states that the salt  $\text{CuO}, \text{C}_6 \text{H}_5 \text{O}_3 + \text{H}_2\text{O}$  does not possess the properties so minutely described before, but that they refer to another propionate of copper, which is to be discussed farther on ; it is not stated what becomes of the paramorphism which had so elaborately been demonstrated as existing between the salt previously examined and the acetate of copper.—As for the trustworthiness of the crystallographic determinations, suffice it to say Nicklès communicates certain measurements of angles, according to which the sum of the angles of a six-sided prism =  $711^\circ$ , (in cyanuric ether he simply assumes that in the combination  $\infty \text{P} . \infty \tilde{\text{P}} \infty$  each of the 4 angles  $\infty \text{P} : \infty \tilde{\text{P}} \infty$  was as much less than  $120^\circ$  as each of the

(1) Annual Report for 1847 and 1848, Vol. I.

(2) Laur. u. Gerh. Compt. Rend. 1849, 347.

(3) Ibid. 348.

(4) Ibid. 367.

(5) Laur. u. Gerh. Comt. Rend. 1849, 452.

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2 angles  $\infty P : \infty P$  larger than  $120^\circ$ ). Nicklès believes that the planes of truncation of the two different edges of a rhombic prism are only at right angles to one another, when the prism itself is a right rhombic one; and in acetate of baryta, containing 3 atoms of water (if we place confidence in Brooke's measurements, as we ought to do), he has confounded similar and dissimilar planes with one another.—The following may show his mode of drawing conclusions: Nicklès tries to demonstrate analogies in the forms of two bodies, by comparing one of the forms in a fixed position, to the other, first in one, then in a different position; and by assuming the angles which have been found in both positions as a proof of a similar elaboration. He finds that in different salts, of similar acids, containing various amounts of water, there is something constant, namely: prisms with angles of  $80-82^\circ$ ; and something variable: the more obtuse terminal acuminations, the more water there is in the salt: and he not only pays no attention to the fact that the planes of acumination are sometimes similar, and sometimes dissimilar, but also that they sometimes rest upon the more acute, at others upon the more obtuse edges of the prism. From the above we are now justified(1) in not following the author into the detail of his crystallographic statements, or into the exposition of the laws which he thinks he has discovered, viz.: that the salts of the acids  $C_n H_n O_4$  are isomorphous when they contain corresponding amounts of water; that they are hemimorphous when they differ in that respect; that analogous ethers are isomorphous or (which he states to be the same) paramorphous; that the corresponding salts of analogous organic bases are isomorphous; that salts of the same organic base, but of different acids, are hemimorphous; that glycocine occurs in two different forms, and that its salts may be arranged in two groups, according as they contain the glycocine of one or the other form; that however the two forms of glycocine and all its salts are hemimorphous, that malic acid and tartaric acid are probably hemimorphous, and that the bitartrate of ammonia and bimalate of ammonia are isomorphous.

**Relations between Composition and Specific Gravity.**—Avogadro(2) has published a treatise on the necessity of distinguishing between the weights of chemical equivalents, and the weights of the *molécules intégrantes* in investigating the specific or atomic volumes. He states that the equivalent of a substance does not necessarily represent the relative weight of an integral molecule, but that the latter may be a multiple or an aliquot part of the former; that therefore the true atomic volume is by no means represented by the quotient obtained by dividing the equivalent weight by the specific gravity, but that it

(1) See also Marignac's opinion, Arch. Ph. Nat. XII, 236.

(2) Arch. Ph. Nat. XI, 285.

is a simple multiple, or submultiple of this quotient. He considers that the atomic volume of gaseous elements is always to be assumed equal; that in others it is found to vary even after reduction (multiplication or division of the above-mentioned quotient by 2, 3, or other numbers), but in such a manner that a greater atomic volume belongs to the more electro-positive, a smaller one to the less electro-positive, elements. Avogadro has endeavoured to give a numerical expression to the electro-chemical state of bodies, and terms the numbers he has adopted, numbers of affinity; he thinks he has discovered that the relation between the numbers of affinity is as the cubic roots of the atomic volumes. We are unable to examine the detail of his proofs and arguments, as the treatise throughout has reference to former investigations of his own.

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Naumann has tested the view he formerly(1) expressed with regard to the condensation of the atoms of water in mixtures consisting of acid and water by comparison with Bineau's more recent experiments on the sp. gr. of dilute sulphuric acid(2). He found that this view is confirmed with regard to the more concentrated mixtures, but not for those which contain more water than  $\text{SO}_3 + 3\text{HO}$ .

W. A. Miller(3) has endeavoured to use Pierre's observations on the sp. gr., and the boiling-points of various fluids(4), in order to test the positions advanced by H. Kopp: that the boiling-points of two analogous substances, possessing a difference of composition of  $x \text{ C}_2 \text{ H}_2$ , differ by a constant value, about  $x \cdot 19^\circ$ , and that there is a similar difference between the specific volumes of every two such substances, by a constant value of about 18.7(5). Miller is of opinion that these assumptions are in opposition to facts, as the numbers resulting from Pierre's observations, which should be actually identical, exhibit too many discrepancies. We subjoin these numbers, and also add those which result from H. Kopp's observations(6). A comparison between the two shows that the chief discrepancies which Pierre has observed are contradicted by Kopp's experiments, and that the results obtained by several observers for the same substances, differ much more than the differences between

(1) Annual Report for 1847 and 1848, Vol. I, 33.

(2) J. Pr.-Chem. XLVI, 385.

(3) Chem. Soc. Qu. J. I, 363.

(4) Annual Report for 1847 and 1848, 44.

(5) Kopp had on a former occasion (Ann. Ch. Pharm. XLI, 79) pointed out that the spec. volumes of analogous compounds of ethyl and methyl differ at the *ordinary* temperature by about 18.7; he has since (Ann. Ch. Pharm. L, 71) determined the difference of the spec. volumes for a difference of composition  $\text{C}_2 \text{ H}_2$  and for the *boiling temperatures of the substances in question*, more accurately at about 21.8 (the numbers of spec. volumes of course refer to the atomic weights adopted in this Report).

(6) Annual Report for 1847 and 1848, 48.

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the individual numbers, which, according to Kopp's view, ought to be identical.

Result of a Comparison of	For $C_2H_2$ the difference of the			
	boiling-points according to the experiments of		spec. volumes according to the experiments of	
	Pierre.	Kopp.	Pierre.	Kopp.
Alcohol and pyroxylic spirit . . . . .	12.0	12.9	19.3	19.9
Iodide of ethyl and iodide of methyl . . . . .	26.2	—	17.5	—
Bromide of ethyl and bromide of methyl . . . . .	27.7	—	20.0	—
Acetate of ethyl and acetate of methyl . . . . .	15.6	18.0	14.7	23.6
Butyrate of ethyl and butyrate of methyl . . . . .	16.9	18.9	36.9	23.5
Acetate of ethyl and formiate of ethyl . . . . .	21.2	19.4	20.0	22.7
Butyrate of methyl and acetate of ethyl . . . . .	27.9	21.6	7.0	18.8
Butyrate of ethyl and acetate of ethyl . . . . .	17.4	20.2	13.5	21.1
Butyrate of methyl and acetate of methyl . . . . .	21.3	19.8	10.4	21.2
Butyrate of methyl and formiate of ethyl . . . . .	24.6	20.5	13.1	20.8
Butyrate of ethyl and formiate of ethyl . . . . .	22.0	20.0	21.0	21.7
Butyrate of ethyl and acetate of methyl . . . . .	19.8	19.5	19.3	22.0
Hydrated oxide of amyl and alcohol . . . . .	17.8	17.6	20.3	20.3
Hydrated oxide of amyl and pyroxylic spirit . . . . .	16.3	16.4	20.1	20.2

This table might rather be considered as a proof in favour than against Kopp's doctrine.

**Thermology. Sources of Heat. Evolution of Heat in Chemical Combination.**—Favre and Silbermann(1) have measured the quantity of heat evolved during the combination of oxygen, chlorine, bromine, iodine, and sulphur, with some metals and non-metallic substances. In most instances, it was necessary to make the determination in an indirect manner; and here the principle was adopted that the heat which becomes latent when two elements are separated is equal to the heat given off when these elements combine with each other.

*Chlorine* was combined with *hydrogen* in the calorimeter, the hydrochloric acid formed was absorbed by a large quantity of water, and the product, in the form of chloride of silver, weighed. 1 grm. of hydrogen develops with chlorine 23783 heat-units.

Direct union of *chlorine* with *metals* could only be effected in the case of copper. Other metals had either to be dissolved in dilute hydrochloric acid, or their anhydrous oxides were combined with dilute hydrochloric acid. The latter method may be employed to check the former, but is only available if the metal is not attacked by dilute hydrochloric acid. In either case the product remains in solution. In order to obtain the results for the anhydrous product, the heat has to be added, which becomes latent during the process of solution in the water.—The heat of combination of *iodides* and

(1) Compt. Rend. XXVIII, 627; Arch. Ph. Nat. XI, 124; Ann. Ch. Pharm. LXXII, 206.

*bromides* may be obtained in the same way, or we may subtract the amount of heat developed during the substitution of chlorine for bromine and iodine from the heat of combination of the respective chloride.

The heat of combination of *metals with sulphur* may be deduced in the same way, after previously ascertaining the heat evolved during the combination of sulphur and hydrogen. The latter was determined by measuring the heat produced by allowing hydro-sulphuric acid to act upon a solution of sulphurous acid in water; the chemical process that takes place in this case, is expressed by the formula  $\text{SO}_2 + \text{aq.} + 2 \text{HS} = 2 \text{HO} + 3 \text{S} + \text{aq.}$  The numbers for the alkaline sulphides were obtained by the action of sulphuretted hydrogen upon solutions containing the oxides in excess; and those for the insoluble metallic sulphides by the mutual decomposition of alkaline sulphides and metallic salts.

The heat of combination of the various metals with *oxygen* was determined in three different ways:—1. By the action of water on the alkali-metals, in which case the evolution of heat is due to three different causes, namely, to the combustion of the metals, to the combination of the oxides with water, and to the decomposition of the water. 2. By dissolving a metal in dilute hydrochloric acid. 3. By the precipitation of one metal by another.

The results obtained under the supposition of the product being anhydrous, are given in the following table:

Heat-units developed by the union of one equivalent of metal with

	O	Cl	Br	I	S
Potassium . . . . .	—	101527	90319	77414	45672
Sodium . . . . .	—	95485	—	—	—
Zinc . . . . .	42450	50296	—	—	20663
Iron . . . . .	37609	49036	—	—	16788
Hydrogen . . . . .	34462	23783	9322	—3606	2748
Lead . . . . .	27722	45542	32504	*22932	9164
Copper . . . . .	22569	30208	—	—	9542
Silver . . . . .	7505	35159	26667	18977	6443

Favre and Silbermann are of opinion that in order to render these results available for comparison they must be reduced for the case of dilute solution, as in the solid state the different aggregation of the molecules exerts an influence. If the calorific effects for the state of solution and for 1 equiv. of the metals be calculated, constant differences are observed between the chlorine-, bromine-, and iodine-compounds, &c., of the different metals; they have been termed moduli of the eqivs. of heat by Favre and Silbermann.

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1 Equivalent of the Metals.	O	Cl	Br	I	S	Difference between the Eq. of Heat of the Metal and Potassium.
Potassium . . . . .	76239	97658	85814	72625	51003	—
Sodium . . . . .	73509	94988	83200	69800	48343	— 2700
Zinc . . . . .	—	56566	44778	31378	—	— 41200
Iron . . . . .	—	52735	40947	27547	—	— 45000
Hydrogen . . . . .	34462	40192	28404	15004	—	— 57400
Lead . . . . .	—	42188	30400	1700	—	— 55400
Copper . . . . .	—	35183	23395	9995	—	— 62500
Silver . . . . .	—	19151	7363	—6037	—	— 78500
Modulus of the substitution of a non-metallic substance for oxygen.	—	+ 21400	+ 9600	—3600	—25200	—

Chloride, bromide, and iodide of silver\* are insoluble; but the numbers given above have been calculated from nitrate of silver, as nitric and hydrochloric acids, &c. evolve the *same* amounts of heat when combining with the same base to form a *soluble* compound. The table shows that the quantities of heat evolved by hydrogen and the metals bear nearly the same ratio as the affinities assumed in chemistry.—The communications made by Favre and Silbermann, during a series of years, of the results of their researches on the heat of combination, only now and then permit an insight into their mode of experimenting and conducting their calculations; without which full confidence cannot be placed in the value of their conclusions. On the other hand, the frequent boldness of the hypotheses upon which they base their inferences, and which are often even made the foundation from which they deduce their numerical results, is less calculated to supply that defect than to excite suspicion.

Favre and Silbermann have also discovered by the reaction of chlorine upon ammonia, that during the combination of hydrogen and nitrogen to form 1 equiv. of ammonia, 22724 heat-units are evolved.

In a subsequent treatise(1), Favre and Silbermann have measured the amount of heat evolved during the absorption of gases by charcoal.

	heat-units.	1 grm. charcoal absorbed
1 grm. hydrochloric acid gas evolved . . . . .	232.5	69.2 cubic cent.
1 „ sulphurous acid gas . . . . .	139.9	83.2 „
1 „ carbonic acid gas . . . . .	129.6	45.2 „

These quantities are greater than the corresponding quantities of

(1) Compt. Rend. XXIX, 449; Instit. 1850, 43; Ann. Ch. Pharm. LXXII, 209.

heat rendered latent by evaporation; for sulphurous acid gas the latter is = 94.56 heat-units.

Favre and Silbermann also found the

Latent heat of evaporation of iodine . . . . .	= 23.95
Sum of the sp. heat from 180° to 107° . . . . .	7.90
Latent fusion-heat . . . . .	11.71
Sum of the sp. heat from 107° to 20° . . . . .	4.71
<hr/>	
Difference of heat in vapour of iodine of 180°, and in solid iodine at 20° . . . . .	= 48.27
Sp. heat of liquid iodine . . . . .	= 0.10822
Sp. heat of solid iodine . . . . .	= 0.05412 (Regnault.)

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Here, as in water, the sp. heat of the solid substances is half of what it is in the fluid state.

In a report on the development of heat in chemical processes made to the *British Association*, Andrews(1) observes that every change in the molecular condition of matter is attended by an evolution or absorption of heat, and that the quantity of heat evolved or absorbed, bears a definite relation to the amount of mechanical or chemical activity. He makes the following separate propositions: a solution of a salt in water is always attended by an absorption of heat. If equal quantities of the same salt are successively dissolved in the same fluid, the amount of latent heat decreases with each fresh addition of salt.—If a salt is dissolved in a fluid which already contains other salts, less heat is absorbed than if the salt is dissolved in pure water. When salts are dissolved in dilute mineral acids more heat is generally absorbed than if they are dissolved in water.—The amount of heat evolved during the combination of acids with bases, is determined by the basis, and not by the acid. One equivalent of a base in its combination with various acids almost always evolves the same amount of heat.—When a neutral salt is converted into an acid salt by combination with one or more equivalents of acid, no heat is evolved(2); nor is there more in the union of two neutral salts to form a double salt.—On the other hand, when a neutral salt is converted into a basic one, heat is evolved.—If a precipitate is formed on mixing two neutral salts, there is invariably a trifling but a definite evolution of heat. The same report published results obtained relative to the combination of metals with acids, oxygen, chlorine, iodine, and bromine. In proof of substances in various allotropic states evolving different quantities of heat when forming the same chemical combinations, Andrews quotes the combustion-heat of charcoal at = 8080, of graphite = 7778, of diamond = 7824.

(1) Chem. Gaz. 1849, 407; Instit. 1849, 382; Ann. Ch. Pharm. LXXII, 210,

(2) This in no way agrees with the results obtained by Favre and Silbermann, see Annual Report for 1847 and 1848, Vol. I, 37, 38.



Mechanical  
equivalent  
of heat.

**Mechanical Equivalent of Heat.**—In answer to the claims put forward by Joule(1), which we have quoted in the last Annual Report, Mayer(2) has proved that he not only was the first, in 1842, to state the proposition expressing the equivalence of heat and mechanical power, and to give its numerical value, but that he actually based it upon undoubted and well-known physical data.

Meanwhile, Joule has made some improvements in the apparatus, by means of which he determined the mechanical equivalent of heat, by friction in water, oil, and mercury(3); as the mean of forty experiments, he has found the equivalent of heat =  $423\cdot3$  metergrammes(4), which number he believes to be correct within  $\frac{1}{1000}$  of its actual value.—Joule looks upon the following points as settled by the results of his investigations:—1. The experiments on the friction of fluids confirm the views and observations of Davy and Rumford, that heat is not a substance, but a mechanical effect. 2. As the heat-effects occurring during the condensation and rarefaction of the air are equivalents of the mechanical force consumed, it follows that the heat of elastic fluids consists only in the *vis viva* of their particles. 3. The zero of heat, as deduced from the expansion of gases, is  $278^{\circ}\cdot5$  below the freezing-point of water.—It would be desirable that Joule had explained his conclusions more fully. His method of calculating the sp. heat of gases, from the mechanical effect which they produce, leads to results which materially differ from those obtained by the observations of de la Roche and Bérard.

**Expansion by Heat.**—Regnault(5) found the relation of the coefficients of expansion of atmospheric air under nearly ordinary pressure to that of a 2·4 fold pressure, between  $0^{\circ}$ , and  $-87^{\circ}\cdot9$  as  $0\cdot003665 : 0\cdot0036754$ , and the relation of the coefficients of expansion of atmospheric air and hydrogen within the same limits of temperature as  $0\cdot003665 : 0\cdot0036467$ .

**Specific Heat; Fusion; Latent Fusion-Heat.**—Regnault, as is well known, has been led by his investigations on specific heat to conclude that not only in protoxide of silver, but also in potassa and soda, one atom of oxygen should be assumed in combination with two of the metal, so that in their atomic composition these oxides would correspond to suboxide of copper; from which it follows that the atomic weights of silver, potassium and sodium, are only to be assumed at half of what they are generally adopted in reference to that of oxygen, lead, &c., and of what we have given them in the Annual Report.

(1) Compt. Rend. XXVIII, 132 and 199.

(2) Compt. Rend. XXIX, 534.

(3) Annual Report for 1847 and 1848, Vol. I, 41.

(4) Report of the 18th British Association, Not. and Abstr. 21.

(5) Ann. Ch. Phys. [3] XXVI, 257; Compt. Rend. XXVIII, 325; Instit. 1849, 90; Pogg. Ann. LXXVII, 99; J. Pr. Chem. XLVII, 188.

The cause for this assumption is, that then the law, by which in elements and chemical compounds of a similar constitution the sp. heats are approximately in an inverse ratio to the atomic weights, holds good also for substances which form an exception if their ordinary atomic weights and atomic formulæ be retained. In support of his assumption, he now (1) quotes experiments which he has instituted on the sp. heat of potassium. This must be determined at low temperatures, as potassium is soft at the ordinary temperature, and contains a portion of its fusion-heat in a latent state. Regnault's method of experimenting consisted in cooling known quantities of potassium or lead by surrounding them with solid carbonic acid, and determining the reduction of temperature which the substances caused in a known quantity of petroleum. By this means he found the sp. heat of potassium to be 5.83, 5.77, 5.40 times that of lead (the last determination he considers the most trustworthy); according to the ordinary view the atomic weight of lead is 2.64 times that of potassium, but 5.29 times, if we adopt the assumption of Regnault; in the latter case the above-mentioned law would also hold good for potassium.—In the same way, and with the assumption that the sp. heat of lead at low temperatures does not materially differ from that found (0.0314) between  $0^{\circ}$  and  $+100^{\circ}$ , Regnault determined the sp. heat of phosphorus between  $-78^{\circ}$  and  $+10^{\circ} = 0.1740$ , and that of ice within the same limits of temperature  $= 0.474$ .

Regnault (2) determined the sp. heat of lead in a direct manner, between  $-77^{\circ}.75$  and  $+10^{\circ} = 0.03065$ .—By experiments in which mercury, cooled down to  $-77^{\circ}.75$ , was introduced into water of nearly the ordinary temperature, and the reduction of temperature determined, the spec. heat of solid mercury between  $-40^{\circ}$  and  $-77^{\circ}.75$  was fixed at 0.3136 and 0.03247; in this experiment it was assumed that the sp. heat of liquid mercury between  $-40^{\circ}$  and the ordinary temperature is equal to what it is between the latter, and  $+100^{\circ}$  (0.03332), and that the latent fusion-heat of mercury is, according to Person (3)  $= 2.82$ .—The sp. heat of bromine as determined by Andrews (4) (0.107 between  $45^{\circ}$  and  $11^{\circ}$ ), does not agree with the law of Dulong and Petit; Regnault has also instituted new investigations into this subject. He found the sp. heat of liquid bromine (the freezing-point being  $-7^{\circ}.32$ )  $= 0.11294$  between  $+58^{\circ}$  and  $+13^{\circ}$ ,  $= 0.11094$  between  $+48^{\circ}$  and  $+10^{\circ}$ ,  $= 0.10513$  between  $+10^{\circ}$  and  $6^{\circ}$ . He determined the sp. heat of solid bromine between

Sp. heat;  
fusion;  
latent  
fusion-  
heat.

(1) Ann. Ch. Phys. [3] XXVI, 261; Compt. Rend. XXVIII, 325; Instit. 1849, 81; Pogg. Ann. LXXVII, 99; J. Pr. Chem. XLVII, 121.

(2) Ann. Ch. Phys. [3] XXVI, 268; Pogg. Ann. LXXVIII, 118; J. Pr. Chem. XLVII, 468.

(3) Annual Report for 1847 and 1848, Vol. I, 58.

(4) Ibid. Vol. I, 65.

Sp. heat;  
fusion;  
latent  
fusion-  
heat.

—  $78^{\circ}$  and  $-20^{\circ}$  as a mean at 0.08432, and its latent fusion-heat at 16.185, by ascertaining the reduction of temperature produced in the water of the calorimeter by solid bromine of various degrees of cold. The first number agrees with the law of Dulong and Petit, if half the equivalent of bromine be taken for its atomic weight.

In continuation of his former investigations (1) Person (2) has communicated more accurate data (which do not invariably agree with what he has formerly published) on the subject of sp. heat and latent fusion-heat.

The fusing-point of crystallised chloride of calcium ( $\text{CaCl}_2, 6 \text{H}_2\text{O}$ ) he found to be  $28^{\circ}5$ ; the sp. heat of the solid salt (below  $0^{\circ}$ ) = 0.345, of the liquid salt (as a mean between  $80$  and  $33^{\circ}5$ ) = 0.555. He found the latent fusion-heat = 40.70; when calculated according to Person's formula (3) from the preceding data, it is = 39.58.

He determined the fusing-point of crystallised phosphate of soda ( $2 \cdot \text{NaO}, \text{H}_2\text{O}, \text{PO}_5 + 24 \text{H}_2\text{O}$ ) at  $36^{\circ}4$ , the sp. heat of the solid salt below  $0^{\circ}$  = 0.4077. Salt that had been fused and again solidified exhibited a greater and variable sp. heat, 0.676 to 0.776, which Person accounts for by the solidifying salt not forming the same chemical combination as the crystallised salt; the latter was only produced during the solidification of the fused salt, if there was an excess of water; therefore in making his experiments on the sp. heat of the liquid salt, and the latent fusion-heat, he provided for a slight excess of water, for the presence of which he made an allowance in his calculation. He thus found the sp. heat of the fluid salt between  $80^{\circ}$  and  $40^{\circ}$  = 0.7467, the latent fusion-heat = 66.80; the latter he calculates according to his formula at 66.48.—Person points out that crystallised phosphate of soda possesses the same sp. heat, as is exhibited by a mixture of ice and anhydrous phosphate of soda (pyrophosphate of soda), having the same composition; and he renders it probable that the same relation holds good for the sp. heat in the fluid state, and for the latent fusion-heat.—When 100 grms. of crystallised phosphate of soda were mixed with 80 grms. of crystallised chloride of calcium (both in a state of minute division), a reduction of temperature of from  $+20^{\circ}$  to  $-29^{\circ}$  took place.

Person found that by fusing together 1 equiv. of nitrate of potassa, with 1 equiv. of nitrate of soda, we obtain a mass possessing a constant fusing-point ( $219^{\circ}8$  of the air-thermometer). He discovered the sp. heat of this substance, below  $60^{\circ}$ , to be 0.235; when fused, between  $340^{\circ}$  and  $230^{\circ}$ , = 0.352. The latent fusion-heat deduced from this is 44.5. The latter proved, on observation,

(1) Annual Report for 1847 and 1848, Vol. I, 54.

(2) Ann. Ch. Phys. [3] XXVII, 250; Compt. Rend. XXIX, 300 (in abstr.).

(3) Annual Report for 1847 and 1848, Vol. I, 55.

to be higher, =51.4; but he remarks that the double-salt, on cooling, exhibits the same phenomenon as certain alloys(1), viz: a sudden evolution of heat below the point of solidification; if this quantity of heat, which is not liberated by a change in the molecular constitution until the occurrence of solidification, is allowed for in the computation, the latent fusion-heat, as observed, corresponds entirely with the result of calculation.—Person calculates the latent fusion-heat of the double-salt moreover in another way, from the latent fusion-heat of nitrate of potassa and soda at 219°.8. We have already communicated the mode in which he makes these calculations, in reference to a case which is perfectly analogous(2).

Sp. heat;  
fusion;  
latent  
fusion-  
heat.

The fusing-point of the yellow bees'-wax of commerce he found to be 61°.8, the sp. heat between 100° and 65°=0.499; between 58° and 42°=1.72; between 42° and 26°=0.82; between 26° and 6°=0.504; between 3° and -21°=0.4287. Person justly remarks, that in this case the heat, which, from the experiment, would appear as the sp. heat of the solid body, contains a certain amount of latent-heat, consumed in softening and incipient fusion; he argues, that in substances like wax, the true sp. heat for the solid state can only be determined at very low temperatures, and even then not without being affected by the fusion-heat.—Spermaceti behaves like wax; the fusing-point of the former was determined, by Person, at 42°.7, the sp. heat between 100° and 44°, =0.5292, between 3° and -21°, =0.3855.

Person gives farther explanations of his views regarding the relations between latent fusion-heat, and the sp. heat in the solid and liquid states; and between latent fusion-heat, and the coefficient of elasticity. He had formerly found(3), that the latent fusion-heat of several non-metallic substances is expressed by the formula,  $l = (160 + t) d$ ,  $l$  being the latent fusion-heat,  $t$  the fusing-point,  $d$  the difference between the sp. heat of the body when solid and when liquid. He had also discovered(4), that there is a connection between the latent fusion-heat and the coefficient of elasticity, which may be expressed by the formula

$$l : l_1 = q \left( 1 + \frac{2}{\sqrt{p}} \right) : q_1 \left( 1 + \frac{2}{\sqrt{p_1}} \right)$$

( $q$  and  $q_1$  are the coefficients of elasticity,  $p$  and  $p_1$  the sp. gravities,  $l$  and  $l_1$  the latent fusion-heats of two metals); by the introduction of a coefficient, which he determines by observations made on zinc into the latter formula, he deduces the term

$$l = 0.001669 \left( 1 + \frac{2}{\sqrt{p}} \right)$$

(1) Annual Report for 1847 and 1848, Vol. I, 62.

(2) Ibid. Vol. I, 57.

(3) Ibid. Vol. I, 55.

(4) Ibid. Vol. I, 100.

Sp. heat;  
fusion;  
latent  
fusion-  
heat.

He now expresses the latent fusion-heat of a body by the following general formula

$$l = (160 + t) d + 0.001669 \left( 1 + \frac{2}{\sqrt{p}} \right)$$

the second part indicates the amount of heat necessary to separate the molecules, and liquify the substance; whilst the first represents the amount of heat necessary to modify, or even to split the molecules; the first part is stated to disappear in metals, in which it is proved, experimentally, that  $d=0$ ; whilst the second part has a trifling value in the non-metallic substances, which only possess a slight amount of tenacity.

Person gives a description of a calorimeter, in which every correction caused by the influence of the surrounding temperature of the media is avoided to the utmost, by enveloping the calorimeter itself in a layer of water, the temperature of which is always to be kept the same as that of the water in the calorimeter; for particulars we refer to the treatise, and the drawing which accompanies it.

**Influence of Strong Heat on various Bodies.**—Despretz has instituted experiments on the effect produced upon various substances by intense heat. In the first series of experiments(1) he concentrated the effects of various sources of heat, a battery of one hundred and eighty-five of Bunsen's elements of the ordinary size, a lens of 90 centimeters in diameter, and a hydrogen-jet. Whilst under the influence of the battery alone, magnesia became pasty; under the influence of the battery and the lens, magnesia was volatilised in white fumes, and acicular pieces of anthracite, 1 millimeter in thickness, and 3 centimeters in length, became pliable; when exposed to the influence of the battery, the lens, and the hydrogen-jet, the anthracite appeared to fuse.—In a second series of experiments(2), he allowed four hundred and ninety-six of Bunsen's elements, which were arranged in four rows, in such a manner that they were equal to one hundred and twenty-four elements of fourfold size to act upon a little rod of sugar-charcoal (4 millimeters in thickness, by 5 centimeters in length), in a rarefied space. The carbon was volatilised, and deposited on the surface of the glass, in the shape of a black, crystalline powder.—In a third series(3), he employed six hundred of Bunsen's elements, arranged in six rows. Silicium rapidly fused to a globule, and then scratched glass; boron is more fusible and volatile: the experiments with both these substances were made in an atmosphere of nitrogen. Titanium (prepared in the shape of a brownish powder from the bichloride), on being heated in

(1) Compt. Rend. XXVIII, 755; Instit. 1849, 193.

(2) Compt. Rend. XXIX, 48; Instit. 1849, 225.

(3) Compt. Rend. XXIX, 545; Instit. 1849, 369.

a crucible of sugar-charcoal, under the bell of the air-pump, was almost entirely volatilised, and formed a reddish-brown metallic deposit on a porcelain dish placed over it; this deposit was of a beautiful blue in nitrogen; the non-volatilised residue formed white, or whitish-yellow laminæ, and globules presenting, on being polished, a pale golden yellow surface; their hardness was less than that of metallic tungsten, but nearly equal to that of corundum. Metallic tungsten, when heated in nitrogen in the same manner, formed a slightly brown deposit on the superimposed porcelain dish, and was fused into a hard mass, whose fracture resembled that of hard steel; it was even capable of scratching polished surfaces of ruby. 80 grammes of palladium, and 250 of platinum, were easily fused.—In a fourth series of experiments(1) he arrived at the following results: that carbon is evidently volatilised *in vacuo* under the influence of from 500 to 600 of Bunsen's elements, disposed in five or six rows; that volatilisation also takes place, but more slowly, in a gas; that at the temperature produced in this manner the charcoal can be bent, welded and fused; that every variety of coal becomes softer in proportion to the time it is exposed to the heat, and that it is finally converted into graphite; that the purest graphite is gradually volatilised like the other varieties of carbon, but that the residuary substance in experiments of this kind still continues to be graphite; that the diamond, like other coal, is converted into graphite(2) under the influence of such heat; and like other coal, when heated for a sufficient period, yields small fused globules; finally, that the formation of the diamond by the influence of powerful heat upon organic or carbonaceous substances is improbable.

Influence  
of strong  
heat on  
various  
bodies.

**Ebullition.**—Regnault(3) has determined the boiling-point of carbonic acid and protoxide of nitrogen. An air-thermometer, the ball of which was surrounded with solid carbonic acid that evaporated spontaneously, exhibited in various experiments a temperature of  $-77^{\circ}.92$  (the barometer showing  $767^{\text{mm}}.3$ ),  $-77^{\circ}.75$ ,  $-78^{\circ}.16$ , the last determination being considered as the most correct by Regnault; the thermometer showed nearly the same temperature  $-78^{\circ}.26$ , when placed in an evaporating mixture of solid carbonic acid and ether. For experiments in which it is desirable to cool substances strongly, such mixtures are more serviceable than carbonic acid alone, because they are better conductors of heat.—Protoxide of nitrogen, when evaporating in the atmosphere, invariably showed  $-87^{\circ}.904$ ; Regnault intends examining the variations of the boiling-point which this substance presents in reference to the variations of the barometer.

(1) Compt Rend. XXIX, 709. Instit. 1849, 401 (in abstr.).

(2) Jacquelin's Experiments in the Annual Report for 1847 and 1848, Vol, I, 253.

(3) Loc. cit. 20.

Latent  
heat of  
aqueous  
vapour.

**Latent Heat of Aqueous Vapour.**—According to Joule(1) the  $536^{\circ}$  of latent heat in steam saturated at  $100^{\circ}$ , are so distributed that  $42^{\circ}$  are employed as *vis viva* by the pressure, and the remaining  $494^{\circ}$  are considered as the actual heat of vaporisation; so that in an atmospheric engine without expansion, of  $536^{\circ}$  which the boiler contains,  $494^{\circ}$  pass into the condenser, and only  $42^{\circ}$  are rendered available.

**Spheroidal State.**—Boutigny(2) has confirmed the fact, that the hand may be immersed into molten iron, bronze or lead, without being burnt(3). He states the experiment to succeed well when the skin is moist; or better if the hand is rubbed with soap and smoothed, and then immediately before the experiment immersed in a cold solution of chloride of ammonium saturated with sulphurous acid, or simply in an aqueous solution of chloride of ammonium. Boutigny explains the fact by assuming that the hand does not come into direct contact with the molten metal, as the moisture of the former at once passes into the spheroidal state(4).—He farther reports(5) that the finger moistened with water perceives in molten lead the temperature of the water which is in the spheroidal state; if moistened with alcohol, it receives the impression of moderate warmth; if with ether, an agreeable sensation of cold. The latter experiments cannot be made with fused iron, as it ignites alcohol and ether. Boutigny is of opinion that bodies in the spheroidal state are bounded by a layer of matter, the molecules of which are so combined, that the layer may be compared to a solid envelope which is transparent, extremely thin and very elastic. He endeavours to prove this by the observation, that the currents which take place in the interior of a fluid presenting the spheroidal state, and which may be demonstrated by substances, *e.g.* charcoal minutely divided, never extend to this external layer.

**Tension of Vapour.**—Groshans(6) has communicated observations on the corresponding temperatures, the boiling and freezing points of bodies. If the elasticity of aqueous vapour is termed  $p$ , the density of the vapour  $d$  (the density at the boiling-point, and under a pressure of  $0^{\text{m}}.76=1$ ), an optional temperature  $t$ , and the coefficient of expansion  $c$ , we have  $p = d \frac{1 + ct}{1 + c \cdot 100}$ . If in another body the density of the vapour (the density at the boiling-point and under a

(1) Instit. 1849, 368.

(2) Ann. Ch. Phys. [3] XXVII, 54; Compt. Rend. XXVIII, 593; J. Pharm. [3] XVI, 24; Ann. Ch. Pharm. LXXI, 295; Phil. Mag. [3] XXXV, 60.

(3) Former observations on this point in Gehler's Physik. Wörterbuch, neue Bearbeit. X, 503; Plücker's confirmatory experiments with fused iron, Pogg. Ann. LXXVIII, 425; Phil. Mag. [3] XXXVI, 137; Instit. 1850, 111; Arch. Ph. Nat. XIII, 140.

(4) Annual Report for 1847 and 1848, Vol. I, 69.

(5) Ann. Ch. Phys. [3] XXVIII, 158; Compt. Rend. XXIX, 471; J. Pharm. [3] XVI, 424.

(6) Pogg. Ann. LXXVIII, 112.

pressure of  $0^{\circ}76=1$ ), is termed  $d$ , the boiling-point  $= E$ , and a temperature corresponding to  $t = T$ , we have  $p = d \frac{1 + c T}{1 + c E}$ . Tension of vapour.

As for corresponding temperatures,  $p$  has the same value in both formulæ,  $d$  also possesses a similar value in both, and it follows that  $\frac{1 + c t}{1 + c \cdot 100} = \frac{1 + c T}{1 + c E}$ , from which the following formulæ result:

$$T = \frac{(1 + c E)(1 + c t)}{(1 + c \cdot 100) c} - \frac{1}{c} \quad (1)$$

$$t = \frac{(1 + c \cdot 100)(1 + c T)}{(1 + c E) c} - \frac{1}{c} \quad (2)$$

$$E = \frac{(1 + c \cdot 100)(1 + c T)}{(1 + c t) c} - \frac{1}{c} \quad (3)$$

With the assistance of these formulæ we are enabled to determine all corresponding temperatures, if the boiling-point  $E$  is known; and *vice versâ*, if a single corresponding temperature has been observed, the boiling-point may be deduced.

Groshans also points out that in several bodies, if the temperature which corresponds to the temperature  $0^{\circ}$  of water be sought for by means of the formula No. 1, we obtain temperatures which closely correspond to the freezing-points of these bodies; in other words, it follows that the tension of the vapours of many bodies at their freezing-point is equal to that of water at the same temperature.

He also thinks that he has discovered several other facts regarding a law-like connection between density of vapour, boiling-point and atomic weight, and between boiling-point and atomic constitution; he admits, however, that they only apply to a limited number of substances, and even with regard to these rest upon very gratuitous assumptions. We are obliged to refer to the treatise itself.

For the relations existing between composition and boiling-point *vid. supra*, p. 15.

Brame(1) has employed sulphur in a state of very minute division, in which he terms it sulphur-vesicles (*utricules de soufre*), (comp. p. 7) as a test for the vapour of mercury. He states it to be much more delicate than gold leaf. He thus finds that the vapour of mercury at  $12^{\circ}$ , rises above 1 meter; that even at  $8^{\circ}$  it appears to have no limited atmosphere, that at the ordinary temperature, it evaporates from amalgams and mercurial ointments; that in the presence of sulphur-vapour and air, it is diffused according to the law of diffusion of gases; and that



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the air.

it appears not to follow this law in the presence of atmospheric air and iodine-vapour, nor of the vapour of iodide of mercury which is then formed.

**Tension of Aqueous Vapour in the Air.**—Regnault in his researches on the tension of aqueous vapour *in vacuo* and in the atmosphere, had observed the former to be constantly rather higher than the latter(1), but admitted that the trifling difference (about  $\frac{1}{2}$  millimeter), probably depended upon a constant error, which he had not yet succeeded in discovering. Victor Pierre(2) has endeavoured to determine this point; but his method appears but little adapted to the purpose, as the limits of errors are much more extensive than those in Regnault's experiments. His first results appeared to indicate a still greater difference between the tension *in vacuo* and in the atmosphere than Regnault had found; whilst 90 measurements which he has since published(3) argue an identity of tension *in vacuo* and in the atmosphere; these were conducted at ordinary temperatures (between  $10^{\circ}$  and  $20^{\circ}$ ), and are, therefore, less liable to error.

Hopkins(4) points out that if we calculate the weight of the vapour in a column of air from the surface of the earth upward, by the tension which the vapour has at the surface, we obtain much too high a result. The reason being that the tension and density of the vapour of water at the surface is not the result of the pressure of the superincumbent column of vapour only, but also of the resistance of the atmosphere which is mixed with it, and which prevents the rapid diffusion of the vapour.

Although meteorological notices scarcely come within the scope of the Report, the results obtained by Dove(5) on the amount of vapour contained in the atmosphere and the course of barometric variations, based as they are upon numerous good observations in all zones, present too great an interest to be passed over in silence. As the vapour of water chiefly rises from the great surfaces of water presented by the sea and lakes, and spreads over the land; and as the latter, on account of its greater capability of being heated, causes less precipitation in summer than in winter, Dove concludes that there is little difference in the amount of vapour in sea- and land-air in summer, but that in winter it diminishes as we recede from the coast to the interior of the continents. In fact, during the warmest months the elasticity of the vapour at the coast and in the interior of the continents under the same latitude differs but little, whilst the former exceeds the latter

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(1) Ann. Ch. Phys. [3] XV, 129; Pogg. Ann. LXV, 141.

(2) Wien. Acad. Ber. 1849, April, 267.

(3) Wien. Acad. Ber. 1849, June and July, 30.

(4) Instit. 1849, 351.

(5) Pogg. Ann. LXXVII. 369; Berl. Acad. Ber. 1849, 145; Instit. 1849, 348; Arch. Ph. Nat. XII, 305.

considerably in winter. In January it is 3''' in Cornwall, and only 0'''·5 in the interior of Asia. Dove also found that at all points of observation of the hot and temperate zones, the elasticity of the vapour contained in the air increases with the rise of temperature; that this increase is most considerable in progressing from the colder to the warmer months in the district of the monsoons, and especially at the northern boundary, that it is somewhat more considerable in North America than in Europe, under the same latitude, because the direction of the winds there is more southerly in the summer-months than in winter, while the reverse is the case in Europe. Dove's tables(1) give the monthly mean of the tension of vapour, of the entire atmospheric pressure, and of the pressure of the dry atmosphere at 74 stations in Europe, America and Asia, on the northern as well as the southern hemisphere.—Dove has pointed out in former treatises the utility of separating the pressure of vapour from that of dry air in investigations on atmospheric pressure; and explained how by this means the great daily and annual barometric variations which occur in sea- and inland- and mixed-climate(2) may be united under one point of view(3). The value, nay, the necessity of this mode of viewing the matter, has been demonstrated anew. The maximum of atmospheric pressure of the southern hemisphere corresponding in time to our summer, does not compensate the minimum of this pressure in the summer of the northern hemisphere; over Asia there is a greater deficiency than is supplied in the south, consequently there must be in addition to the exchange of the atmosphere between the two hemispheres a lateral discharge. In order to estimate the extent of this exchange, the portion which at one time assists in bearing the column of mercury, and at another passes in the liquid state underneath the barometer, must be eliminated. Although in all latitudes the amount of vapour increases from the cold towards the warm months, it would still be the same for the whole earth at the same period if the relation between the solids and liquids were the same under all latitudes. In fact, the entire amount of vapour undergoes an annual periodic variation to which the dry air is not subject; the latter only suffers a change of position, and it is, therefore, the more necessary to consider both separately.

Tension of  
aqueous  
vapour in  
the air.

Lastly, Dove shows that the atmosphere is at no time of the year in a state of equilibrium, and that the points to which the current of the air is directed in the inferior, and from which it passes in the upper, regions, vary within the annual period. It is only by attending to the monthly barometric curves that the secondary causes of movement can be separated from the primary ones, and that a

(1) Pogg. Ann. LXXVII, 383 to 396.

(2) Pogg. Ann. XXII, 219, 234; LXX, 372.

(3) Pogg. Ann. LVIII, 177.

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closer insight can be obtained into the meteorological processes.—We must refer to the treatise itself for the detail, and especially for the variations of the amount of atmospheric vapour in different localities.

**Hygrometer.**—Lefebvre(1) has tested Regnault's condensing hygrometer(2), by comparing it with the contemporaneous indications of several chemical hygrometers. The points of the appearance and disappearance of dew at a temperature of  $17^{\circ}$  to  $24^{\circ}$  were observed. The mean values only differed by 1 per cent in the indication of the state of moisture from that of the chemical hygrometer; the point at which the dew appeared showed a nearer approach to the chemical hygrometer than its disappearance. Comparison instituted with Daniell's hygrometer, presented considerable differences.

**Radiation of Heat. Reflection of Heat from Metals.**—Provostaye and Desains have found(3) the universally adopted opinion(4), that all kinds of heat-rays are equally reflected by metallic surfaces, to be incorrect. The heat-rays of a Lokatelli's lamp were reflected in the following ratios :

Metals.	Direct Radiation.	Radiation through Glass of 5mm in thickness.	Radiation through Rock-salt.
Speculum Metal .	0.835	0.74	0.825
Silver . . . .	0.955	0.91	
Platinum . . .	0.79	0.655	0.775

It follows that those rays which pass through glass with the greatest facility are reflected by metals in a minor degree than other rays. On the other hand, the loss experienced by a pencil of heat-rays in passing through glass, must prove relatively more considerable, if it has previously been once or oftener reflected from metallic surfaces. This fact has been irrefragably demonstrated by experiment.

**Interference of Heat-rays.**—Seebeck(5) has employed Fraunhofer's "grating spectra," in order again to confirm the interference of heat-rays, although this had been positively proved by the experiments of Fizeau and Foucault(6), as well as by those of Knoblauch(7). He conducted sun-light, by means of a glass mirror, through a fissure of 1.25in. into a dark room, and let it fall upon a telescope, 10 feet

(1) Ann. Ch. Phys. [3] XXV, 110; Pogg. Ann. LXXVII, 152.

(2) Ann. Ch. Phys. [3] XV, 129; Pogg. Ann. LXV, 135 and 321.

(3) Ann. Ch. Phys. [3] XXVII, 129; Compt. Rend. XXVIII, 501; Instit. 1849, 122; Arch. Ph. Nat. XI, 44; Phil. Mag. [3] XXXIV, 471; Pogg. Ann. LXXVIII, 131; Ann. Ch. Pharm. LXXII, 136 (in abstr.).

(4) Lamé Cours de Phys. 1840, III, 368 and 369; Péclet. Traité de Phys. 4. édit. I, 387; Dove, Repert. der Phys. 1841, IV, 344; Melloni, Ann. Ch. Phys. [2] LXXV, 371.

(5) Pogg. Ann. LXXVII, 574, from the Ber. der Math. Klass. d. K. Gesellsch. d. Wiss. zu Leipzig; Ann. Ch. Pharm. LXXII, 138 (in abstr.).

(6) Annual Report for 1847 and 1848, Vol. I, 92.

(7) Ibid.

distant, before the object-glass of which a fine grating (100 divisions to a Paris line) was applied. After the passage of the light through the eye-glass, a well-defined white field is observed in the middle, at both sides of this, dark spaces, and then the first spectra, &c. The black ball of Leslie's thermometer was first introduced into the middle, then into the dark spaces, and lastly into the first spectra. The mean values obtained by Seebeck for the three positions, were 2.05, 0.34, 1.1; which distinctly proves the interference of the heat-rays. In a second experiment which was conducted with a more delicate thermometer, the light passed through an opening of 1.5 in. in the shutter, and was received at a distance of 15 feet. The mean values in this case were 7.8, 0.9, 3.0.

Interference of heat-rays.

**Polarisation of Heat-rays.**—Provostaye and Desains(1) have instituted an investigation into the polarisation of radiant heat, which serves as a supplement to the researches of Knoblauch(2). Sunbeams were thrown upon an achromatic prism of Iceland-spar, by an heliostat; one of the two pictures that were formed was received upon a screen, the other passed through an aperture; and then, after going through the necessary reflections and refractions, struck upon a thermo-electric pile. The deviations of the galvanometer gave the measures of the intensities. On the principal section of the prism being directed horizontally, and the ordinary ray that was polarised in this plane being reflected by a mirror placed perpendicularly, at an angle of  $56^\circ$  upon the pile, a deflection of  $75^\circ$  was observed; whereas, if the prism was revolved  $90^\circ$ , the needle remained at perfect rest. This is a proof of the complete polarisation of both pencils, which were, moreover, found to be perfectly identical in point of intensity.

On splitting a polarised heat-pencil by a doubly-refracting prism, the law of Malus relative to the intensity of both pencils was proved to be perfectly applicable. Let  $a$  be the angle formed by the principal section with the original plane of polarisation, the following intensities,  $i$ , were obtained:

$$\begin{array}{cccc} a = 30^\circ & i = 0.75 & a = 45^\circ & i = 0.50 \\ & 35 & 52 & 0.379 \\ & 0.67 & & \end{array}$$

$i$  in every case =  $\cos^2 a$ .

The law of Fresnel, that in the reflection of polarised light from glass, according to whether the plane of polarisation is parallel or perpendicular to the plane of incidence, the intensities of the reflected ray are,

$$I = \frac{\sin^2(i-r)}{\sin^2(i+r)} \quad \text{or} \quad I' = \frac{\text{tg}^2(i-r)}{\text{tg}^2(i+r)}$$

(1) Compt. Rend. XXIX, 121; Instit. 1849, 241 and 276; Ann. Ch. Phys. [3] XXVII, 109; Ann. Ch. Pharm. LXXII, 139 (in abstr.).

(2) Annual Report for 1847 and 1848, Vol. I, 90.

Polarisation of heat-rays.

was likewise fully confirmed for the heat-rays, as proved by the following numbers, in which the index of refraction of the black glass is assumed to be 1.52.

1. The heat polarised in the plane of incidence :

Angle of Incidence.	Observed.	Calculated.
	Intensity.	
90°	100	100
80	55.1	54.6
75	40.7	40.8
70	30.6	30.8
60	17.99	18.3
50	11.66	11.7
40	8.08	8.1
30	6.12	6.1
20	5.03	5.0

2. The heat polarised perpendicularly to the plane of incidence :

90°	100	100
80	24.00	23.6
75	11.00	10.6
70	4.34	4.15
28	3.00	2.91

Reflection from metallic surfaces gave the following results :

	Steel.		Speculum Metal.		Platinum.		Silver.	
	I.	II.	I.	II.	I.	II.	I.	II.
30°	0.64	0.566	0.669	0.618	0.47	0.373	0.80	0.845
50°	0.694	0.468	0.740	0.579	—	—	0.87	—
70°	0.834	—	—	—	0.75	0.31	0.936	0.81
72° 5	—	—	0.895	0.415	—	—	—	—
76°	0.87	0.271	—	—	—	—	—	—
80°	0.90	0.29	0.938	0.440	0.862	0.38	0.954	0.83

It is obvious that the intensity of the ray that is polarised in the plane of incidence grows with the angle of incidence, whilst the ray that is polarised perpendicularly to the plane of incidence descends to a minimum of intensity, and then again increases. The minimum of reflection appears to take place for platinum and silver at 70°; for speculum metal at 72° 5; for steel at 76°.

Here too the heat exhibits a deportment which is entirely analogous to that of light; this is demonstrated by a comparison which the authors institute between their own results and those which Jamin(1) has obtained in regard to light and the values calculated according to Cauchy's formulæ. They also convinced themselves that half of the sum of the intensities of the rays polarised in the two planes is

equal to the intensity of the unpolarised heat which is reflected at the same angle of incidence.

Polarisation of heat-rays.

The same inquirers(1) also investigated the state of polarisation of the heat-rays proceeding from heated bodies, and found that the relation between polarised and unpolarised heat cannot differ much for luminous and non-luminous sources of heat. Provostaye and Desains employed for their investigation a column, consisting of two laminae of gypsum, upon which the rays, which proceeded from the source of heat at an inclination of  $70^\circ$  to the normal, formed an angle of incidence of  $55^\circ$ . Under I. we give the deflections of the galvanometer, occurring when the plane of emission of the rays is parallel with the plane of refraction of the gypsum column. II. applies to the case of the two planes being perpendicular to one another.

Source of Heat.	I.	II.	Relation of the two Deflections.
Red-hot platinum foil . . . .	24 <sup>0</sup> .5	8 <sup>0</sup> .3	2.95
The same, rather below red-heat	11 <sup>0</sup> .2	3 <sup>0</sup> .5	3.20
Perfectly dark platinum . . . .	4 <sup>0</sup> .5	1 <sup>0</sup> .5	3.00

Poisson had found it difficult to reconcile the existence of the equilibrium of temperature in spaces which neither receive heat from without, nor discharge it outwards, with the fact of polarisation by reflection; in order to remove the difficulty he had assumed that the dark heat-rays are not polarised, while on the introduction of luminous heat-sources the equilibrium of temperature does not continue.—This assumption is inadmissible, as the polarisation of the dark heat-rays is proved; besides, it is unnecessary, if we consider that the heat which is emitted by a surface-element, is partly reflected and partly radiated from the substances; and that these two amounts of heat are polarised in planes, which are perpendicular to one another, and consequently bear the relation of natural heat, if they are equal in point of intensity.

**Rotation of the Plane of Polarisation by the Magnet.**—As the analogy existing between light- and heat-rays has not been in any way disproved, it was to be expected that an action of the magnet upon the plane of polarisation of the heat-rays would be observed; as Faraday has discovered an action in the case of light.—We reported last year(2) that Wartmann thought he had observed such an action; it has now been indubitably proved by Provostaye and Desains(3). They conducted a sunbeam that was reflected by the heliostate,

(1) Compt. Rend. XXIX, 757 (in abstr.); Ann. Ch. Pharm. LXXII, 141.

(2) Annual Report for 1847 and 1848, Vol. I, 191.

(3) Ann. Ch. Phys. [3] XXVII, 232; Pogg. Ann. LXXVIII, 571; Compt. Rend. XXIX, 352; Instit. 1849, 322; 1850, 27; Phil. Mag. [3] XXXV, 481 (in abstr.); Ann. Ch. Pharm. LXXII, 144; Arch. Ph. Nat. XII, 136.

Rotation  
of the  
plane of  
polarisa-  
tion by the  
magnet.

through an apparatus of polarisation, consisting of two achromatic calc-spar prisms. The polarised heat had to pass, between the two prisms, through a layer of flint-glass, of 38<sup>mm</sup> in thickness, which was placed between the two poles of an electro-magnetic apparatus of Rumkorf.—The thermo-pile which the heat-rays impinged upon last, was placed at a distance of 4 meters from the electro-magnet, the needle was removed still farther. It was not in the slightest degree affected by the electro-magnet, either when at rest or when deflected. As long as the flint-glass was not introduced, the needle retained its position unaltered, whether the current was interrupted, or whether it passed in one (A) or the other direction (B). In five series of experiments with the flint-glass, the following deflections were obtained :

Current A .	21.2	22.8	19.5	14.9	21.7
No Current .	18.8	20.5	18.3	11.8	18.4
Current B .	—	18.5	17.2	8.7	14.9

We may therefore conclude that there is no doubt about the magnet producing an effect upon the flint-glass, and through it upon the plane of polarisation of the heat-rays. Provostaye and Desains point out that in these experiments it is best to cross the two prisms of the polarising apparatus at an angle of 45°, as the difference  $\cos^2 (45^\circ - \delta) - \cos^2 (45^\circ + \delta) = \sin 2\delta$  is considerably greater than  $\cos^2 (90^\circ - \delta) - \cos^2 90^\circ = \sin^2 \delta$ . For light the crossing must certainly be under 90°, as the eye is less capable of distinguishing differences of light than of estimating the entire absence of light.

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**Kinetics. Forces in General. Inertia of Matter.**—L. Thines-Csetneky(1) has made an attempt to introduce a new axiom in physics, which, however, so far as we are able to judge of the author's deductions, neither rests upon a sound basis, nor has led to results of any consequence.

Weighing is generally considered as the simplest mode of determining the quantity of matter contained in a given space; it being assumed that the weights of really equal quantities of matter of various known substances are equal.—Thines-Csetneky is of opinion that physicists have blindly and thoughtlessly adopted this assumption of the astronomers, for whose purposes it undoubtedly suffices. The assumption, according to his view, leads to the conclusion of the infinite compressibility of matter. The author does not, however,

(1) *Physikalischer Beitrag zur Chemie*, Linz, 1849.

state how this conclusion is arrived at. But he requires that, on the contrary, it be assumed that the same force, *e. g.* gravitation, produces an unequal effect upon equal quantities of matter of a different chemical nature, or that different values of inertia (*i*) appertain to these equal quantities of matter (*s*); consequently the product  $s \cdot i$  is what has hitherto been designated mass (*m*) or  $m = s \cdot i$ .—We may undoubtedly assume every quantity subdivided into an unlimited number of factors; but if we do so to quantities of a physical character, it is imperative that the reality of the factors be proved, *i. e.* that the facts be adduced which lead to their assumption. All phenomena of motion have hitherto been accounted for without viewing matter apart from its fundamental property of inertia. Thines-Csetneky's new doctrine starts from the laws of isomorphism. He contends that when isomorphous substances are mutually substituted, equal quantities of matter should replace one another. As in this case, very unequal weights replace one another, as for instance, 35.5 chlorine are replaced by 127 iodine, the only alternative that remains is unequal inertia, by which equal quantities of matter, though under the influence of the same force, still produce an unequal pressure on the scale.—As Thines-Csetneky does not assume a continuity of matter, but even concedes the existence of intervals between the atoms and molecules, there is no reason why he should substitute the idea of equal quantities of matter for atoms and surrounding spheres of equal volume. He evidently offends against the fundamental maxim of Newton, that we should not assume more causes of natural phenomena than are necessary or sufficient for their explanation.—If indeed equal quantities of matter were necessary to fill equal spaces, dilatation by heat would increase the quantity of matter, and if the amount of inertia depended upon the chemical character, it would appear very remarkable that the weight of the compound is always equal to the weight of the component parts.—As Thines-Csetneky in deducing his conclusions, takes for granted the equation upon which his considerations are based, as well as the numerical values of the constants which he employs, we are incapable of forming a judgment upon them.

**Motion without Force.**—Boucheperon(1) has again renewed the attempt to deduce the law of motion of the heavenly bodies from the mere resistance of the æther; he admits of no gravitation, and even accounts for the laws of motion generally by reference to the impenetrability and inertia of matter without the assumption of a force. These absurd attempts are not novel, nor are they likely to find much support; it is therefore unnecessary to say any more on the subject.

Kinetics.  
Forces  
in  
general.  
Inertia of  
matter.



Equilibrium of  
solids.  
Parallelo-  
gram of  
forces.

**Equilibrium of Solids. Parallelogram of Forces.**—Pratt, in his work on mechanics, has founded his demonstration of the parallelogram of forces upon the equation

$$\left\{ f(\vartheta) \right\}^2 + \left\{ f\left(\frac{\pi}{2} - \vartheta\right) \right\}^2 = 1.$$

He now(1) communicates a solution of this equation, by which  $f(\vartheta) = \cos \vartheta$ .

Ettingshausen(2) has given the proof of the direction of the resultant of two forces acting at a right angle in a new form; it requires the determination of the function from the condition

$$f(x) + f(y) = f\left(\frac{x + y}{1 - xy}\right)$$

which can only be done with the assistance of the higher branches of analysis.

**Elasticity. Coefficient of Elasticity.**—Forbes(3) has used the apparatus of s'Gravesande for the purpose of measuring the modulus of elasticity of steel.—If the steel wire be stretched horizontally by a weight  $T$ ,  $s$  being the length, and  $D$  its depression, caused by a weight  $P$ , attached in the middle, the modulus of elasticity can be calculated from the approximate formula  $P = 2 T \cdot \frac{D}{s}$

+  $M\left(\frac{D}{s}\right)^3$ . Forbes found in steel  $M = 89 \cdot 000 \cdot 000$  grains; 1 foot of wire weighed 11 grains, consequently  $M = 19303$  kilogrm. for a transverse section of  $1 \square^{\text{mm}}$ , assuming the sp. gr. at 7.83.

**Coefficient of Elasticity determined by Torsion.**—In consequence of the establishment of a museum of measures and weights, destined to contain the standards of all the European states, Kupffer has been induced to enter upon experimental investigations into the elasticity of metals and their expansion by heat; he has published some of the results obtained in reference to the former property.(4)—He proceeded according to Coulomb's method: to the end of a wire, 10.5 feet long, a rectangular rod was attached and suspended horizontally; weights were now suspended from the rod in pairs at equal distances from the centre; he then observed the time of the vibrations produced by the torsion of the wire. For this purpose a small mirror was applied in the prolongation of the suspension-wire, from which, by means of a telescope placed at some distance, the divisions of a scale surrounding the apparatus, could be read. The time of the

(1) Phil. Mag. [3] XXXIV, 201.

(2) Wien. Acad. Ber. 1849, Februar, 155.

(3) Phil. Mag. [3] XXXV, 92.

(4) Petersb. Acad. Bull. VII, 289.

vibrations was calculated from the formula  $t = T (1 - \alpha \sqrt{s})$  (for very small vibrations), which was deduced from the experiments themselves;  $T$  is employed to designate the observed,  $t$  the calculated time of vibration,  $s$  the amplitude,  $\alpha$  is a constant which varies in different metals; whence it follows that the increase in the time of a vibration with an increasing amplitude certainly does not depend exclusively upon the atmospheric resistance, but also upon the nature of the elastic substance.—Kupffer has discovered that when the surfaces become very considerable, the reduction is no longer in proportion to the square roots of the amplitudes. In all his own experiments, this relation continued applicable. The reduction to the *vacuum* has a considerable value; it is independent of the time of the oscillations.

Coefficient  
of elasticity  
determined by  
torsion.

Let  $l$  represent the length of the wire,  $r$  its semi-diameter,  $J$  the momentum of inertia of the weight, and  $t$  the time of vibration, then we obtain  $n = \frac{\pi^2 J}{g \cdot t^2}$ ,  $\mu = \frac{n l}{r^4}$ ,  $\delta = \frac{1}{5\mu}$ ;  $n$  representing the weight which applied to the rod at the distance  $l$  from the centre, causes it to describe an arc equal to the radius,  $\mu$  designating the same weight for a cylinder, the height and radius of which  $= 1$ , and  $\delta$  the elongation of the same cylinder by the weight-unit attached at the lower end. The coefficient of elasticity is easily calculated from the quantity  $\delta$ , and Kupffer found by this method,

Iron	No. 1.	18571	Platinum	15924
„	No. 2.	17850	Silver	7080
Brass		9446	Gold	6794

The numbers represent the weight in kilogrammes, which would double the length of a wire of 1 square millimeter in section.

Kupffer subjoins a few comparative observations on the effect of heat and of external tractile powers.—A cylinder, the height and semi-diameter of which  $= 1$ , is warmed  $1^\circ$  by  $md\pi^2$  heat-units,  $m$  being the sp. heat, and  $d$  the density of the substance. The elongation thus produced must, consequently, be proportional to  $md\pi^2 \cdot \delta$ , so that if  $\alpha$  represents the expansion of the metal by heat,  $\alpha = c \cdot md \cdot \delta$ . The value of  $c$  calculated from the experiments made with iron, brass, platinum and silver amounted indeed so nearly to the same magnitude, that the coefficients of expansion calculated from the mean, differed but very slightly from those obtained by observation.—Kupffer also calculates that the heat required to elevate the temperature of a cylinder of water of the above-mentioned form, from  $0^\circ$  to  $100^\circ$ , exerts a pressure of 4352 atmospheres.

The coefficient of elasticity increases with the temperature in the same manner as the coefficient of expansion. Kupffer deems it probable that the former also increases with the tension, and purposes deciding this question by a future series of experiments.

Coefficient  
of elasticity  
determined by  
torsion.

We have mentioned, on a former occasion(1), that Wertheim was induced by the results of his experiments on the elongation of elastic rods, to attribute a different value to a constant in Cauchy's formulæ. This does not alter the relations hitherto observed between the coefficient of elasticity on the one hand, and the velocity of sound, the longitudinal and lateral vibrations or the flexion, on the other; but it modifies those existing between the coefficient of elasticity and the angle of torsion and the vibration of torsion. If  $q$  is the coefficient of elasticity, and  $l$  the length of the rod, which describes the angle  $\psi$  by a force  $P$ , applied at the distance  $R$ , Wertheim(2), gives the formula  $q = \frac{16}{3} \frac{PRl}{\pi r^4 \psi}$ , for a cylindrical rod of the radius  $r$ ; for a prismatic rod, the square transverse section of which has the side  $h$ , adopting Saint-Venant's(3) corrections, he makes  $q = \frac{16 PRl}{0.841 \cdot h^4 \cdot \psi}$ ; if a cylindrical rod, whose weight  $= p$ , makes  $n$  rotatory vibrations in a second, we obtain  $P = \frac{\pi^2 \cdot p \cdot r^2}{2 g \cdot n^2}$ . Wertheim has employed the experiments of Coulomb(4), Duleau(5), Savart(6), Giulio(7), and Bevan(8) in order to calculate with the aid of the above formulæ, the coefficient of elasticity of cast-steel, of several varieties of iron and copper, and of brass; he thus arrives at results which completely accord with the values found by elongation and lateral inflection.—The relation of the number  $n$  of the longitudinal vibrations of a rod that is fixed at its centre and free at its extremities, to the number  $n'$  of the vibrations of torsion, determined by Poisson at  $\frac{n}{n'} = \sqrt{\frac{5}{2}}$   $= 1.5811$ , now proves to be  $\frac{n}{n'} = \sqrt{\frac{3}{2}} = 1.6330$ . Savart's experiments led him to the number 1.6668, Wertheim by his experiments with cast-steel, iron and brass, obtained 1.6309.—The alteration in the equations of elasticity above alluded to has thus again been confirmed.

Based upon the development which we communicated in the last Annual Report, Saint-Venant(9) has employed the values of  $\frac{n}{n'}$  deter-

(1) Annual Report for 1847 and 1848, Vol. I, 96.

(2) Ann. Ch. Phys. [3] XXV, 209

(3) Annual Report for 1847 and 1848, Vol. I, 95.

(4) Mém. de l'Acad. 1784.

(5) Navier, leçons de mécan. à l'école des Ponts et Chaussées, I. 105.

(6) Ann. Ch. Phys. [2] XLI, 373.

(7) Mém. de l'Acad. de Turin, 1842, 329.

(8) Phil. Trans. 1829.

(9) Compt. Rend. XXVIII, 69.

mined by Wertheim, which have just been quoted, in order to discover in what ratio the coefficient  $G$  (*coefficient d'élasticité de glissement*) is smaller than the true coefficient  $E$  (of elongation). From older and more recent experiments, he arrives at the mean  $\frac{E}{G} = \frac{n^2}{n'^2} = 2.48$ .

Coefficient  
of elasticity deter-  
mined by  
torsion.

Wertheim(1), however, remarks that we cannot rely upon the equations used for obtaining this result, and that the experimental results employed are not available for comparison; whence it follows that the soundness either of the more ancient or recent mathematical theory of elasticity receives no corroboration by results thus obtained.

**Equilibrium of Elastic Solids.**—Clausius(2) has communicated his views on the modification which must occur in the data from which the formulæ for the equilibrium and motion of elastic solids have been calculated. He has not yet developed improved formulæ upon this new basis, still we consider it to be advantageous to follow him in his well-digested considerations.—The last Annual Report(3) contained the announcement that the theory hitherto adopted, indicates in the elongation of an elastic rod from the length  $l$  to  $l + \delta$ , an increase of volume of  $l$  to  $l + \frac{1}{2}\delta$ , whereas the direct measurements of Wertheim gave nearly  $\frac{1}{3}\delta$  instead of  $\frac{1}{2}\delta$ .—Wertheim has attempted, as we also stated, to reconcile the formulæ of Cauchy with his own results by a suitable determination of the constants; Clausius allows this to be perfectly admissible in the equations which Cauchy has developed, as he did not consider an elastic body as an aggregation of molecules, but as a continuous mass(4); the relation of two constants still remains a subject for determination in this case. On the other hand, Clausius finds fault with Wertheim for introducing his experimental result into the formulæ, which are deduced(5) from the consideration of molecular actions, as in these the relation of the constants has no longer to be determined. If three planes parallel to the co-ordinate planes pass through a point  $x, y, z$ , in the interior of an elastic body, and the forces of pressure or traction operating upon them be decomposed according to the three axes, we obtain nine components, among which three pairs of equal components occur, which may be designated as follows(6),

For the plane of $yz$	with	$A,$	$F,$	$E$
$xz$	„	$F,$	$B,$	$D$
$xy$	„	$E,$	$D,$	$C$

(1) Compt. Rend. XVIII, 126.

(2) Pogg. Ann. LXXVI, 46.

(3) Annual Report for 1847 and 1848, Vol. I, 96.

(4) Exerc. de Mathém. III, 160.

(5) Ibid. 188 and 213.

(6) Ibid. 46 and 48.

Equilibrium of  
elastic  
solids.

If the substance is homogeneous, and presents no difference, *e.g.*, of elasticity, in its original condition, in regard to different directions, those six components have the following values(1):

$$A = \left\{ (3R + G) \frac{d\xi}{dx} + (R - G) \left( \frac{d\eta}{dy} + \frac{d\zeta}{dz} \right) + G \right\} \Delta$$

$$B = \left\{ (3R + G) \frac{d\eta}{dy} + (R - G) \left( \frac{d\xi}{dx} + \frac{d\zeta}{dz} \right) + G \right\} \Delta$$

$$C = \left\{ (3R + G) \frac{d\zeta}{dz} + (R - G) \left( \frac{d\xi}{dx} + \frac{d\eta}{dy} \right) + G \right\} \Delta$$

$$D = (R + G) \left( \frac{d\eta}{dz} + \frac{d\zeta}{dy} \right) \Delta$$

$$E = (R + G) \left( \frac{d\zeta}{dx} + \frac{d\xi}{dz} \right) \Delta$$

$$F = (R + G) \left( \frac{d\xi}{dy} + \frac{d\eta}{dx} \right) \Delta.$$

Here  $\xi$ ,  $\eta$ ,  $\zeta$ , represent the displacements of the molecule contemplated in the direction of the three axes, and  $\Delta$  the density of the solid. The forces of pressure or traction are, therefore, dependent upon two constants  $R$  and  $G$ . So long as  $R\Delta$  depends upon the coefficient of elasticity of the substance, we obtain, as Clausius has shown, the signification of  $G$ , if in the above formulæ we make  $\xi$ ,  $\eta$  and  $\zeta=0$ , for we have then

$$A = B = C = G\Delta, \text{ and } D = E = F = 0,$$

or  $A$ ,  $B$  and  $C$  are the tensions which were in operation in the substance under consideration, in its primary state; and if this state was one of equilibrium, and the molecular forces alone operated in its interior, it is evident that  $G\Delta$ , in the above formulæ, represents an external force, *e.g.* atmospheric pressure, which is entirely independent of the internal condition of the body; and that it cannot, as Wertheim required, be subjected to the relation  $G = -\frac{1}{3}R$ . Thus, too, the conclusion ceases to hold good, which Wertheim deduced from this condition(2), viz., that the molecular attraction is inversely as the 14th power of the distance between two molecules, a result which even Wertheim does not appear to have viewed with implicit confidence.

Clausius proceeds to test the hypotheses from which the formulæ of

(1) Exerc. de Math. III, 230.

(2) Ann. Ch. Phys. [3] XXIII, 79: Annual Report for 1847 and 1848, Vol. I, 97.

Cauchy and Poisson, given above, have been deduced. The former reduces the terms of summation contained in the most general form to nine, by assuming(1) that the molecules are arranged symmetrically in relation to three planes which pass through the point  $x, y, z$ , and are parallel to the co-ordinate planes; so that a single molecule is separated by each of the three planes from another which is placed perpendicularly opposite to it at an equal distance; the nine terms are reduced to the constants  $R$  and  $G$  by the farther assumption(2) that the values of the sums are not altered if the three directions be changed, or the entire co-ordinate system be made to revolve.—We are not, however, justified in assuming so regular a disposition of the molecules even in bodies homogeneous and equally elastic in all directions, the opinion commonly adopted being that these bodies should be considered as a confused mass of separate molecular groups arranged in crystalline forms.—Poisson has therefore endeavoured to simplify the number of the above-mentioned terms in a different manner. He assumes that the molecules are so equally distributed between two spherical surfaces of the radii  $r$  and  $r + \delta r$ , surrounding the molecule under consideration, as a centre, that an integration may be substituted for the summation. As this consideration cannot possibly apply to the sphere immediately surrounding the molecule, Poisson has recourse to the very improbable hypothesis, that the effect of the molecules in the immediate vicinity, being very small, may be altogether neglected; he is thus led to a conclusion which has already been pointed out as inadmissible, namely, that there is a definite relation between  $R$  and  $G$ .—Lamé and Clapeyron have likewise constructed equations upon the same basis, which entirely correspond with those of Cauchy and Poisson.

Clausius farther shows that the difference between theory and experience does not result from these objectionable hypotheses, as the same equations of equilibrium are obtained without them and without assuming anything but what is inherent in the nature of the bodies.—He points out, that if we examine the elasticity of a body by compression or expansion, we never arrive at the knowledge of the action of single molecules, but even in the smallest transverse section invariably deal with the aggregate operation of innumerable molecules and molecular groups. He states, that as the experiment only affords mean values resulting from the most varying arrangement of the molecules, in calculating the tensions, the terms above referred to might also be deduced on the assumption of a normal system of molecules; the normal system being one in which a mean, and, consequently, regular distribution of molecules is assumed, so that integration may at once be substituted for summation even for the sphere in their immediate vicinity.

(1) Exerc. de Mathém. III, 227.

(2) Ibid. 228.

Equilibrium of  
elastic  
solids.

However, as there must necessarily be a reason for the non-agreement of theory and experience, Clausius seeks for it in an internal change which bodies suffer under the influence of external forces; this W. Weber terms the secondary effect of elasticity (*elastische Nachwirkung*) and he has studied it in silk threads and metals.—The fact that the coefficient of elasticity obtained from lateral and longitudinal vibrations (especially in Wertheim's numerous experiments) has always proved much more considerable than when derived from elongation-experiments, has been explained by Wertheim as resulting from the heat which is alternately evolved and absorbed during the vibrations; he has accordingly calculated from those numbers, for many bodies, the relation of the sp. heat for a constant pressure to the sp. heat for a constant volume. Wertheim ought, as Clausius observes, to have for this purpose employed the formula

$$K = \frac{1}{6 \frac{r^2}{v^2} - 5}$$

as the question is about the propagation of the vibrations along a rod, and not about their spherical propagation. If this formula be actually employed, the numbers obtained for brass, copper and especially for gold are of such abnormal magnitude, that a second co-operating cause necessarily suggests itself; in fact, it is the secondary effect of elasticity which, not having sufficient time to take place in the vibrations, necessarily renders the coefficient of elasticity obtained by elongation-experiments too small.—In order to render the new assumption available in the mathematical treatment of elasticity, Clausius proposes to consider the condition of equilibrium apart from that of motion.

He states that, to the former, the formulæ of Cauchy are applicable, which he has developed for elastic bodies considered as a continuous mass, as in this case by an experimental determination of the constants, the secondary-effect can be introduced.—That assuming a secondary effect to be impossible, on account of the rapidity of the vibrations, the formulæ hitherto in use may be retained for the state of motion; that in the other case the secondary effect will be taken into account, if in determining the elongations, not only the actual, but also the previous state of the body be regarded. The resulting equations would then serve to exhibit, in addition to the ordinary laws regarding duration, propagation of the vibrations, &c., farther peculiarities; they would, for instance, explain why the duration of the state of vibration varies so much in different bodies, although the external impediments, such as atmospheric resistance and friction may be the same.—As to the actual nature of the secondary effect, Clausius inclines towards the view of Poisson, namely, that the molecules of solids do not operate equally in all directions round

their centre of gravity; he deems it probable that "when a body of this kind is subjected to external forces, which operate unequally upon it on different sides, *e.g.*, when it is extended in one direction, whilst in another it remains free, or is even compressed, that the molecules, besides being displaced, are also slightly turned, as they follow the unequal tensions in reference to the direction of forces." The particles, probably, do not turn in this manner and reassume their previous position immediately on the commencement and cessation of the force.—Finally, we make room for the wish expressed by Clausius, that many physicists may engage in inquiries into the doctrine of elasticity; it cannot as yet be considered as complete, and extended researches are necessary to afford a firm basis for a more extended theory.

**Vibrations of Elastic Plates.**—Poisson had given the theory of the vibrations of elastic plates, which are made to vibrate in their centre. The lowest note of the disc causes the formation of one circular nodal line; the next higher note causes two. Poisson determined the radius of these nodal lines by calculation, Savart by experiment, as follows,

	First note.	Second note.	
Poisson . . . .	0.6806 <i>r</i>	0.3915 <i>r</i>	0.835 <i>r</i>
Savart . . . .	0.6810 <i>r</i>	0.3856 <i>r</i>	0.8414 <i>r</i>

We mentioned in the last Annual Report(1) that Wertheim, in consequence of the results of his observations, had proposed an alteration in the equations of elasticity; he has introduced them into Poisson's formulæ for the vibrations of a circular elastic disc(2), and calculated the radii of the circular nodal lines anew. He has also measured them repeatedly with an iron disc, three brass and three glass discs, the coefficients of elasticity of which had previously been determined by a different method. Wertheim asserts that the new formulæ agree rather better with the results of observation than the old ones; still, even the former do not afford a satisfactory concordance: this he explains by the neglect of certain quantities in the formulæ,—as the weight of the disc, the square, and the higher powers of the thickness; &c.—Smaller discs yield more accurate results, and, according to Wertheim, their vibrations may serve to determine the coefficients of elasticity of crystals, at least, of those belonging to the Regular system.

Kirchhoff(3) has generalised the mathematical theory of the vibrations of an elastic disc, even more than Poisson; he not only finds the concentric, but also the diametrical nodal lines, and by

(1) Annual Report for 1847 and 1848, Vol. I, 96.

(2) Compt. Rend. XXIX, 361; Instit. 1849, 314.

(3) Ibid. 753.



Vibrations  
of elastic  
plates.

their number determines the number of vibrations, or the pitch of the note. His formulæ, however, offer no decision for, or against Wertheim's alteration of the constants of elasticity, as the nodal lines calculated by the latter do not well agree with Chladni's experiments; they harmonise better with some experiments of Strehlke, which have been privately communicated to us, than those calculated with the old constants, but they do not satisfactorily agree with either.

**General Theory of Motion.**—Ostrogradsky(1) has communicated a treatise on the integrals of the general equations of motion.

**Geometrical Laws of Motion.**—Sonnet(2) has published an abstract from a work on the Geometrical Laws of Motion, as an extension of the labours of Poncelet, Poinsot, and others on this subject.

**Problem of Rotation.**—Jacobi(3) has given a new and elegant solution of the problem of the rotation of a body which is not subject to the influence of accelerating forces.

**Equilibrium and Motion of Fluids.**—D'Estocquois(4) has developed the fundamental equations of the equilibrium and motion of fluids, with reference to their consisting of systems of molecules, which are at a certain distance from one another.

Challis(5) communicates the derivation of an equation which he considers absolutely necessary for the theory of the motion of fluids, and which he terms the equation of continuity; the equation hitherto known by that name he proposes to call the equation of the inertia of the substance. If  $\psi = 0$  designates a relation between the co-ordinates  $x, y, z$  of the fluid particle and the time  $t$ , the new equation is:

$$\frac{d\psi}{dt} + \lambda \left\{ \left( \frac{d\psi}{dx} \right)^2 + \left( \frac{d\psi}{dy} \right)^2 + \left( \frac{d\psi}{dz} \right)^2 \right\} = 0$$

in which  $\lambda$  is an arbitrary factor. For the derivation itself, we must refer to the place quoted.

**Hydraulics.**—Boileau(6), assisted by the French Ministry of War, has established a hydraulic observatory in the Artillery School at Metz, and instituted extensive investigations on the course of the water in channels, and over weirs, and through locks. We are only in possession of the reports, made to the Academy by Morin, on

(1) Petersb. Acad. Bull. VIII, 33.

(2) Compt. Rend. XXVIII, 43; Instit. 1849, 9.

(3) Ibid. XXIX, 97.

(4) Ibid. 172.

(5) Phil. Mag. [3] XXXIV, 512.

(6) Compt. Rend. XXII, 215; XXIII, 137; XXIV, 957; XXV, 6; XXVI, 97; XXVII, 484; XXVIII, 110, 173; XXIX, 517; Instit. 1849, 25, 41, 362.

Boileau's rescarches; the treatises themselves have appeared in the "*Recueil des Savans Etrangers.*"

Friction  
of  
water.

**Friction of Water.**—Rawson(1) has communicated experiments on the friction of bodies, such as boats, &c., which rock to and fro in the water. He made cylindrical bodies swing round their axes, first in air and then in water. He ascribed the prolongation of the period of vibration exclusively to friction, and based his calculation upon the assumption that the friction increases with the depth below the level of the water, proportionally to the pressure exerted upon the surface-unit.—The same inquirer has made experiments(2) on the mechanical force necessary to disturb the statical equilibrium of floating bodies of different shapes; neither the results of the latter, nor those of the former experiments, have been published in detail.

**Dynamics of Gases. Passage of Hydrogen through Metals.**—It has been known some time that if hydrogen, escaping by a capillary jet, under a pressure of from 10 to 12 centim., be directed against a sheet of paper, the gas passes on as if there were no paper, so that it heats platinum to redness, at a distance even of several centim. behind the paper.—Louyet(3) has observed, that hydrogen also passes through gold- and silver-leaf,—as spongy platinum, that is wrapped up in several folds of gold- or silver-leaf, becomes red-hot when exposed to a current of the gas. The current also passes through a thin layer of gutta-percha, as obtained from the solution in chloroform, but not sensibly through a thin lamina of glass, as obtained by blowing a glass globe.

**Apparatus.**—We subjoin the following remarks on sundry apparatus:

Perreaux(4) has constructed a spherometer whose three feet, placed at the angles of an equilateral triangle, are moveable; by this means the instrument is available for the measurement of the curvature of lenses of a small diameter.—Brunner(5) also has announced the construction of a new spherometer.—Regnault(6) has reported to the Academy on an improved cathetometer of Perreaux, as well as on a machine for making longitudinal and circular divisions, by the same artist; their object is not so much extreme accuracy, as greater economy for physical laboratories.—Wagner(7) announces a new construction of clockwork, by which, instead of the intermitting jerking motion, we obtain one that is uniformly continuous. The apparatus is also intended to indicate the time in

(1) Instit. 1849, 350.

(2) Ibid. 351.

(3) Bull. de l'Acad. Roy. de Belg. 1848, II, 297; Instit. 1849, 7; Pogg. Ann. LXXVIII, 287; J. Pr. Chem. XLVI, 189.

(4) Compt. Rend. XXVIII, 282; Instit. 1849, 65.

(5) Ibid. XXIX, 742.

(6) Ibid. XXVIII, 528 and 529; Instit. 1849, 129 and 178.

(7) Ibid. XXIX, 701; Instit. 1849, 394.

Apparatus.

different and distant parts of a large establishment or public building, by a single regulator. It will also serve to break and restore an electric current in very short, regular intervals (to  $\frac{1}{100}$  of a second).—Andraud(1) has suggested a syphon with continuous motion; by its long limb it takes up a jet of compressed air, which carries the water up foaming; this escapes by the short limb, and can be thus returned to the reservoir.—We have also to mention a new pumping apparatus by Girard(2), which has been very favourably received by the Commission of the Academy; an hydraulic wheel (*à courbe serpentante*) by Caligny(3); hydraulic machines *à mouvement alternatif et à niveaux constants*, applicable to small currents of water, by Caligny(4); an apparatus for the condensation of gases, by Fortin-Hermann(5); a self-registering barometer, which marks an observation every five minutes during twenty-four hours, by Schultze(6); a barometer, by Stampfer(7), which indicates the mean height of the barometer during any given periods (the barometer is connected with the pendulum of a clock, the movements of which vary according to the elevation or descent of the mercury).—Babinet(8) has described a sympiezometer, which serves for the measurement and distinct recognition of the sudden variations of the barometer dependent upon strong gusts of wind. It consists of a glass vessel, capable of containing about 1 litre, the bottom of which is covered with a few centimeters of water; it is then closed hermetically with a cork, through which a tube, of an inner diameter of 1 to 2<sup>mm</sup>, passes down below the level of the water. By inflation, the air in the vessel is so much condensed as to bear a column of water rising above the vessel. If the vessel is protected by a covering against the influence of temperature, the rise and fall of the column of water shows very trifling variations in the atmospheric pressure. Gusts of wind cause a variation of from 1 to 2<sup>mm</sup>, more powerful ones 3<sup>mm</sup> and upwards; Babinet has never observed gusts which produced a variation of more than from 6 to 7<sup>mm</sup>.

An anemometer has been suggested by Phillips(9), which is based upon the measurement of the quantity of water evaporated by the wind.

**Terrestrial Dynamics. Universal Attraction.**—Ellis has communicated to the *Royal Society* a Treatise by Smythies(10) on the Universal Law of Attraction.

(1) Compt. Rend. XXIX, 502.

(2) Ibid. XXVIII, 308; Instit. 1849, 74.

(3) Instit. 1849, 214.

(4) Compt. Rend. XXIX, 333; Instit. 1849, 276, 299, 404.

(5) Ibid. XXVIII, 8.

(6) Pogg. Ann. LXXVI, 604.

(7) Wien. Acad. Ber. 1849, March, 221.

(8) Compt. Rend. XXVIII, 521; Instit. 1849, 129; Arch. Ph. Nat. XI, 121.

(9) Instit. 1849, 54.

(10) Phil. Mag. [3] XXXV, 234.

**Determination of the Density of the Globe.**—Forbes(1) communicates some remarks on Robinson's proposal to determine the density of the globe by the deflection of the plumb-line, or of the level of a liquid surface caused by the flood-tide in places where, at the time of the spring-tides, it attains a height of about 100 feet, as, *e. g.*, in Annapolis, in Nova Scotia. Forbes demonstrates that even in the most favourable case, the deflection of the plumb-line does not amount to more than 0.5 seconds, and concludes that these measurements cannot therefore possibly lead to a safe result.

Determination of the density of the globe.

**Variation of Gravitation on the Surface of the Globe.**—Stokes(2) has delivered a discourse in the *Cambr. Philos. Soc.* on the changes in gravitation on the earth's surface, which the *Phil. Mag.* reports (*loc. cit.*). The author has, it appears, proposed to himself the determination of a general relation between the form of the surface and the changes in gravitation, by the assistance of the doctrine of potentials, without making any assumptions relative to the distribution of matter in the interior of the earth.—In another part of the Treatise, the author considers the influence of the distribution of sea and land upon the changes of gravitation. Stokes accounts for the gravitation being rather less on the continents than at sea-stations, by the elevation of the surface of the sea at the coast, caused by the attraction of the land, in consequence of which, the elevation of the continents is found too small. Hitherto the ellipticity of the earth, as calculated by observation of the pendulum, has been found too great; a fact which Stokes explains by too great a number of sea-stations having been taken into calculation for the lower latitudes; this evidently depends upon a misapprehension, as, according to the view just given, we should expect the very reverse.—Stokes, finally, gives formulæ of correction for calculating the influence of land and sea upon gravitation: for which, of course, an approximative acquaintance with the elevation of the continents and the depth of the sea, is necessary.

**Intensity of Gravitation on the Ellipsoid.**—Laplace had found that if at any point of a rotating ellipsoid the normal be prolonged to the axis, the intensity of the gravitation at that point is proportional to the length of this normal, and inversely proportional to the square of the diameter of the equator. Roche(3) has generalised this proposition for an homogeneous ellipsoid, with three unequal axes. The gravitation at any point of the surface is proportional to the length of the normal from this point to the section of one of the three principal planes of the ellipsoid, and inversely proportional to the square of the axis perpendicular to this plane.

(1) *Phil. Mag.* [3] XXXV, 95.

(2) *Ibid.* 228.

(3) *Instit.* 1849, 252.

Equilibrium of fluids.

**Equilibrium of Fluids.**—The same mathematician(1) has investigated the equilibrium of fluid masses which, in addition to the attraction of their own molecules, are subject to that of a distant point, which possesses the same angular velocity as the fluid body. The forms are elongated or flattened ellipsoids, according to the magnitude of the angular velocity or of the rotation-moment of the fluid.—The results are employed(2) for the determination of the form of the satellites.

**Flattening of a rotating Fluid Mass.**—Roche(3) quotes a law, discovered by Huyghens, that if in a fluid mass rotating on an axis the centrifugal force at the equator is small compared to the gravitation, the flattening is equal to half the quotient of both forces. Roche proves the correctness of Huyghens' assertion, that this result is independent of the law by which gravitation varies according to the distance; and he remarks that Laplace (*Mec. cel. V. 6*) appears to have been in error in regard to this point.

**Theory of Tides.**—Bronwin(4) directs attention to the imperfection of the mathematical theory of the tides. He states that it does not indicate the retardation of the commencement of these phenomena; so that, apart from special auxiliary hypotheses, theory would make them coincide with the respective phase. He is of opinion, that in order to complete the theory, it is necessary to take into consideration the lateral displacement of the particles of water. The first task that Bronwin undertakes, is to render Laplace's equations integrable by making  $\delta p$ , or the variation of the pressure, a complete variation. We must refer to the treatise for the calculation.

**Dynamics of Earthquakes.**—Mallet(5) has given an interesting account of all the statical and dynamical conditions which precede and accompany earthquakes. He also indicates those points which especially deserve the attention of observers.

**Acoustics. Theory of Undulation. Longitudinal and Lateral Waves.**—A concussion affecting the interior of a medium, which is equally elastic in every direction, gives rise to two kinds of waves, namely, a longitudinal wave, commonly called sound-wave, and a lateral wave, the velocity of which is said by Cauchy to bear to the former the ratio of  $1 : \sqrt{3}$ .—Adopting the alterations which Wert-

(1) *Compt. Rend.* XXVIII, 762; *Instit.* 1849, 193; Report by Cauchy, *Compt. Rend.* XXIX, 376.

(2) *Instit.* 1849, 204.

(3) *Ibid.* 60.

(4) *Phil. Mag.* [3] XXXV, 187, 264, 338.

(5) *Instit.* 1849, 359.

heim(1) has introduced in the formulæ of elasticity, we may now calculate the relation of the velocities as 1:2. As the formulæ are in reality intended for a medium of unlimited extent, an experimental confirmation is almost impossible.—Wertheim is of opinion that a substitute for the required experiment may be found by a more careful attention to the horizontal and vertical concussions accompanying earthquakes; and that we might thus discover the unequal velocity of propagation of two varieties of waves.

The application of the calculation to media of a circumscribed extent appears to offer insurmountable obstacles. Wertheim points out a fact, which he thinks proves that the two wave-trains are present in this case. If a rod, or a fluid column, be made to vibrate longitudinally, we hear, besides the note proper to the longitudinal vibration, its lower octave. Savart(2) attempted to explain this latter note by a lateral inflection of the rod caused by the longitudinal movement. Wertheim, on the other hand, ascribes it to the lateral wave; and in addition to other arguments opposes to Savart's mode of explaining it the fact, that the lower note which he has frequently himself heard is also produced in fluid columns. He considers Savart's explanation here quite inapplicable.

**Propagation of Sound. Velocity of the Propagation of Sound.**—Challis(3) has continued his endeavours to deduce the velocities of undulatory motion in elastic media, and especially of sound in the atmosphere, from the fundamental equations of hydrodynamics. On this matter he has been engaged in constant polemics with Stokes(4).—Challis has discovered in the course of his researches, that we cannot assume the waves in elastic media to be either plane or spherical; they cannot be the former, because according to an investigation of Earnshaw(5), "a plane wave cannot be transmitted through any fluid, unless it extend completely across the medium from boundary to boundary;" and because, according to Challis's deductions from the equations of hydrodynamics, different parts of the wave move with different velocities; spherical waves again are incompatible with the principle of constancy of mass. It is this last point which is chiefly the subject of dispute between the two above-named mathematicians.—Challis does not determine the actual form of the wave; his calculations(6), which do not permit of condensation, conduct him to the following formula for the

(1) *Compt. Rend.* XXIX, 697; *Instit.* 1849, 394.

(2) *Instit.* 1849, 415.

(3) *Phil. Mag.* [3] XXXIV, 88, 284, 353.

(4) *Ibid.* 52, 203, 348.

(5) *Trans. of the Cambr. Phil. Soc.* VI, part. 2, 203.

(6) *Phil. Mag.* [3] XXXIV, 88, 353.

Propaga-  
tion of  
sound.  
Velocity of  
the pro-  
pagation of  
sound.

velocity of propagation:  $v = a \sqrt{1 + \frac{e\lambda^2}{\pi^2}}$ , and by the determination of  $e$ ,  $v = a \sqrt{1 + \frac{4}{\pi^2}}$ , in which  $a$  represents the well-known velocity of sound by Newton. The formula makes  $v = 916.322 \sqrt{1 + \frac{4}{\pi^2}} = 1086.25$  feet, whilst observation has given 1089.42 feet.—The factor  $\sqrt{1 + \frac{4}{\pi^2}}$  here occupies the place of the well-known correction of Laplace, and is almost identical with it in numerical value.—Challis rejects the view, that an increase in the velocity of sound may arise from heat becoming latent or free, according to the rarefaction or condensation of the parts of the waves. He is of opinion that heat is instantly diffused through space, and that an increase of temperature can be effected only in closed spaces in which the walls reflect the heat-rays over and over again in a short period.—Airy has formerly opposed Challis on this point, as Moon(1) has done lately. Challis, however, whilst he again objects to the illogical proceeding of Stokes, states the discussion to be terminated as far as he himself is concerned(2), and to this Stokes gives his assent(3).

Airy, however(4), having published some views relative to plane waves being possible in spite of the above-stated results of Challis, the latter has thought necessary to give another rejoinder(5).—Airy certainly arrives at the same result as Challis, viz., that the farther the wave advances, the less uniform becomes the velocity of the progressive and retrograde motion in waves both of water and of air. He assumes this to be the cause of the well-known curling, breaking, or surge of the wave at its limits; a phenomenon which is always observed when a strong tidal wave is propelled a considerable distance up a river. Airy is of opinion that this interruption of the continuity of the atmospheric waves must induce the conversion of a musical note into a noise. In order to render the analogy between the two phenomena plausible, he adduces the fact, that hissing sounds are not re-echoed, just as broken waves are not thrown back by a perpendicular wall; and, also, that as the broken waves pass along a shingly beach without changing their form, the well-known whisper-

(1) Phil. Mag. [3] XXXIV, 136.

(2) Ibid. 449.

(3) Ibid. 501.

(4) Ibid. 401.

(5) Ibid. XXXV, 241.

ing galleries conduct a gentle whisper, but not musical notes, along the vault.

In his reply, Challis again reverts to Stokes' illogical proceeding, and observes, in reference to Airy's views, that they are opposed to experience, as everyday observation, as well as Biot's experiments, prove that words and musical notes are conveyed unchanged to a considerable distance, and that for this reason the waves must essentially preserve their shape.

Propagati-  
on of  
sound.  
Velocity of  
the pro-  
pagation of  
sound.

**Propagation of Sound in Elevated Regions.**—Martins(1) communicates observations which he has instituted in company with Bravais on the propagation of sound in the attenuated atmosphere of elevated regions. They employed two tuning-forks which gave the note  $c$  for the production of sound; the forks were screwed upon small sounding boxes, and had to be struck with small rods. The first experiment was instituted at St. Cheron, 150<sup>m</sup> above the level of the sea, between 1 and 2 P.M.; the note was heard at a distance of 254<sup>m</sup>, whilst it was audible at 379<sup>m</sup> in the evening at 11.—In a second experiment on the Faulhorn, 2620<sup>m</sup> above the level of the sea, when there was complete stillness, the same note was carried to a distance of 650<sup>m</sup>.—Finally, in a third experiment on the large plateau of Montblanc, 3910<sup>m</sup> above the sea, the note was heard at the distance of 337<sup>m</sup>. If we assume that the intensity of a sound produced by the same means is in the ratio of the density of the surrounding medium, and that it diminishes inversely as the square of the distances; and if we accordingly reduce the distances to which the sound was observed to be carried, to the density of the surrounding air, we arrive at the following numbers:

Place of Observation.	Elevation.	Observed distance of Propagation.	Barometric Pressure, at 0°.	Temperature.	Density of Atmosphere.	Reduced distance of Propagation
St. Cheron	150 <sup>m</sup>	{ 254 <sup>m</sup> 379 <sup>m</sup>	744·3 <sup>mm</sup> 744·7	24° 17°	0·900 0·923	268 <sup>m</sup> 394 <sup>m</sup>
Faulhorn	2620 <sup>m</sup>	550 <sup>m</sup>	558·5	7°·2	0·716	650 <sup>m</sup>
Montblanc	3910 <sup>m</sup>	337 <sup>m</sup>	447·9	— 3°·5	0·637	422 <sup>m</sup>

Martins attributes the greater distance of propagation in elevated regions to the prevailing silence, and considers other influences, such as the absence of atmospheric currents, and dampness, which impair the homogeneous character of the air, of secondary importance.

**Refraction of the Rays of Sound.**—Doppler(2), proceeding upon the conviction that the sound-rays are refracted whilst passing from one medium into another, has proposed to deduce the indices of refraction from the total reflection.—The method which he suggests for performing the experiment as well as the calculation which he bases upon an observation of Colladon and Sturm, prove that Doppler

(1) Instit. 1849, 86.

(2) Wien. Acad. Ber. 1849, May, 322.



Refraction  
of the rays  
of sound.

assumes the sound-rays to be deflected from the perpendicular in their transition from a solid or liquid body into the air, like rays of light; now it is evident that the very reverse must take place, since the index of refraction is nothing else than the ratio of the velocity of propagation in both media.

**Tones produced by the Electric Current.**—The essay of Wertheim(1), which we communicated in our last Annual Report, has induced De la Rive to continue his investigations(2) into the sounds produced by the electric current(3); his views are opposed to those of Wertheim, inasmuch as he believes the sounds to depend not so much upon an external impulse exerted by the electric current, as upon a change of position produced in the molecules in the interior of the substance.

Iron-filings in the interior of a spiral coil are distributed in threads lying parallel to the axis of the coil, as soon as a current is passed through the latter; if the current is intermittent, the threads alternately form and disperse. We may imagine a similar disposition of the molecules in a magnetised iron bar; the molecules vibrate round their natural position of equilibrium, if the current be intermittent. The observation made by Joule, that iron rods are elongated when magnetised, tallies with this view. It is evident that the above-mentioned effects are more marked in soft iron than in hardened steel. If the iron or steel have been magnetised beforehand, the coil, if it operates in a corresponding sense, gives rise to less powerful vibrations; if it acts in an opposite sense it produces more powerful vibrations.

An intermittent current passing through an iron wire, produces the same effect as it would do under the most favourable circumstances when surrounding the wire. The external current is more effective for steel wire, or very thick iron wire. The effect of the intermittent current is diminished in soft iron, but augmented in steel, by the simultaneous operation of the continuous current. The augmenting effect in steel lasts a short time even after the cessation of the continuous current, and disappears by jerks.—All these phenomena are easily explicable, if we assume that the traversing current confers upon the molecules a transverse disposition in the same way as they are directed longitudinally by the surrounding coil, or by magnetising. De la Rive has also illustrated, by means of iron-filings, the transverse effect of the traversing current under various circumstances; he finally adds that Joule has observed iron rods to be shortened under the influence of a traversing current.

If the continuous and intermittent currents are in opposite directions, the tone produced by the latter in soft iron is diminished, and

(1) Annual Report, 1847 and 1848, Vol. I, 120.

(2) Ibid. 121.

(3) Ann. Ch. Phys. [3] XXVI, 158.

an alteration, though no diminution, in the intensity of the sound is heard in steel. In order to ascertain the influence of magnetisation in the case of the intermittent current traversing, De la Rive placed a rod of soft iron on the two poles of an electro-magnet, but prevented metallic contact by interposing a playing card; in order to render any displacement impossible, he laid a considerable weight upon the iron. The intermittent current caused a series of sounds, which became stronger and deeper at the time when the electro-magnet was in activity; this depends upon a stronger oscillation between the longitudinal and transverse position.

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The experiments with other metallic (non-magnetic) conductors, which De la Rive describes in the second section of his treatise, are identical with those which we have communicated in the last Annual Report(1).•

**Reiterated Resonance.**—We revert once more to the treatise of Duhamel(2) on reiterated resonance, concerning which we have already spoken in the last Annual Report(3).—It is an undoubted fact that the same body may, by vibrating, produce several notes simultaneously. It is equally certain that the ear is capable of receiving and distinguishing many notes, the vibrations of which reach it simultaneously. As the atmospheric particles which convey the various wave-systems to the ear can never receive from them more than one resulting motion, it follows necessarily that the ear possesses the power of distinguishing in this resulting motion, the periods of the component wave-trains. For the present we are, however, unable to explain upon what this power depends.—If we assume that these points have been universally acknowledged, the treatise of Duhamel offers nothing new. On the other hand, it is very surprising that Duhamel, after having convinced himself by the experiment detailed in the last Annual Report, that at all points of an elastic plate which simultaneously yields several notes, the corresponding vibrations are actually present, and that therefore all the notes proceed simultaneously, though in different intensity, from each point—it is surprising that in the face of this fact he not only does not retract, but even repeats, a former opinion which is thus directly contraverted.—It is well known that Daniel Bernoulli has mathematically deduced from the laws of motion of elastic bodies the possibility of the co-existence of various vibrations in the same elastic body, which, on account of the simultaneous notes, was assumed to be probable. It is true that all physicists were by no means inclined to admit that the ear could distinguish the periods of the component vibrations in the resulting motion. Still no one raised an objection upon this ground to the manner in which Bernoulli

(1) Annual Report, 1847 and 1848, Vol. I, 121.

(2) Ann. Ch. Phys. [3] XXV, 45; Phil. Mag. [3] XXXIV, 415; Arch. Ph. Nat. X, 52.

(3) Annual Report, 1847 and 1848, Vol. I, 122.

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had characterised the state of vibration. Duhamel, however, thought that he had established, mathematically and experimentally, the following position: If a body is made to vibrate by various causes which would separately produce the notes of which the body is capable (according to its form and elasticity), its surface is divided into a certain number of sections, each of which performs vibrations of different duration. These various periods of vibration belong to the notes that correspond to the causes operating separately, and the result is the same as if we had to deal with several distinct surfaces, each of which vibrated separately.—Duhamel concluded that when a disc, for instance, yielded two distinct notes, the nodal lines therefore being differently arranged, only the second note was audible above the nodal line of its fellow, and in its vicinity. On applying his ear to different portions of a disc, which at the same time yielded a fundamental note and its fifth, the result appeared to confirm his supposition, and Savart's experiments on resonant tubes also corroborated it. Nobody can doubt the correctness of these observations; but they certainly do not justify the above-mentioned position, which is opposed to the admitted theory of Bernoulli. In order to avoid misunderstanding, Duhamel ought publicly to have recanted an opinion which his more recent experience had proved to be incorrect.

This would also have rendered the refutation of Antoine(1) unnecessary. Antoine enumerates the experiments instituted by Mersenne, William Noble, Thomas Pigot, Daniel Bernoulli, Sauveur, and Wallis, to prove the simultaneous occurrence of the different states of vibration in a string, which correspond to the fundamental note and the harmonic upper notes. He moreover attempts a graphic illustration of the states of vibration. His delineation is, however, defective; as, for instance, if the fundamental note of a string is sounded simultaneously with its octave, the centre of the string certainly does not remain at the point of greatest deviation, until the halves which yield the octave return to the opposite state of vibration.—After showing the incompatibility of the facts quoted by him, with the position of Duhamel, Antoine adds some remarks on the violin-bow, which, however, contain nothing new(2).

**Theory of Beats.**—Vincent(3) has published a treatise on beats (*Stösse, Schwebungen, battements*) which is remarkable for its elaborate execution, and for an estimation of foreign merit, and an acquaintance with the foreign literature of the subject, such as is not often met with in French writers.—We only regret that Vincent was unacquainted with, or that he has not noticed, the treatises and remarks on notes of combination by

(1) Ann. Ch. Phys. [3] XXVII, 191; Phil. Mag. [3] XXXVI, 27.

(2) Instit. 1840, 123.

(3) Ann. Ch. Phys. [3] XXVI, 37.

Weber(1), Hållström(2), Röber(3), and Poggendorff(4); the application of his ingenuity might have served to elucidate this subject, which is still enveloped in darkness. The above-mentioned treatises prove that the notes of combination hitherto observed are neither satisfactorily accounted for by the position of Tartini, quoted by Vincent: "If two notes, having the numbers of vibration  $\mu$  and  $\mu'$ , are simultaneously struck, a resulting note is heard in addition, the number of vibrations of which is equal to the common measure of  $\mu$  and  $\mu'$ ;" nor by the remark of Vincent, well-founded as it may be, that augmentation or diminution of the intensity of tone, beat, and resulting note, or note of combination, represent the same phenomenon, and only differ in regard to the frequency with which the same action is repeated.

The beats which are heard under certain circumstances, when two or more notes are struck simultaneously, are well known to have been studied with the most surprising perseverance by the silk-manufacturer, Scheibler, of Crefeld, during the second, third, and fourth decennium of the present century. He has made the most beautiful practical applications of his studies to the measurement of notes, and to the tuning of the organ and the pianoforte(5). Neither Scheibler however, nor other physicists, had sufficiently elucidated the theory of these phenomena. Vincent deserves the merit of having completely remedied this defect; he has discovered both the general law by which, by means of the deviation from purity in a given interval of notes—this deviation being expressed in vibrations—the number of the resulting beats may be determined, or *vice versâ*, the number of the vibrations from that of the beats; he has also given a complete series of formulæ, by which the tables intended for the measurement of notes, or organ-tuning, may be calculated.

The fundamental position of the theory is this: let  $m : n$  be the term for the simplest numerical relation of the numbers of vibration of a given consonance(6),  $km$  and  $kn$ , the actual numbers of vibration of both notes in a given time, then it is necessary, if we wish to produce one beat in the same time, to augment or reduce *either*  $km$  by  $\frac{1}{n}$  or  $kn$  by  $\frac{1}{m}$  vibration.

(1) Pogg. Ann. XV, 216, and XXVIII, 10.

(2) Ibid. XXIV, 438.

(3) Ibid. XXXII, 333 and 492, Plates in Vol. XXXI.

(4) Ibid. 520.

(5) H. Scheibler's *Schriften über musikalische und physikalische Tonmessung und deren Anwendung auf Pianoforte- und Orgelstimmung*, Crefeld, 1838; Lühr, *über die Scheiblersche Erfindung überhaupt und dessen Pianoforte- und Orgelstimmung insbesondere*, Crefeld, 1837; Röber, Pogg. Ann. XXXII, 333 and 492; Plates in Vol. XXXI.

(6) Here and in all our communications on Mechanics, Acoustics, and Optics, the term *vibration* applies to the entire to-and-fro movement.

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Vincent remarks that this position looks quite like a paradox, as the beat results from the coincidence of the maxima of the two wave-trains, but that this appearance vanishes when we consider, 1. That the change in the number of vibrations (as the following deduction will at once prove) is not exactly, but only approximatively, as stated in the position, and 2. That although the beat does not occur exactly at the end of a second, but after the  $kn^{\text{th}}$  vibration of the deep, or the  $km^{\text{th}}$  of the high note, nevertheless, the deviation being a fraction of a vibration, is so small as to be imperceptible.—In the first instance Vincent gives the demonstration of the above position for  $n = 1$ , both in case of an alteration in the higher as in the lower note.—We at once pass on to the proof of the general case.—Let  $m$  and  $n$  be the numbers of vibrations of a consonance, and let them be prime to each other, let  $\frac{m'}{n'}$  be the nearest fractional approximation to  $\frac{m}{n}$ , obtained

by converting the latter into a continued fraction,  $\frac{km + m'}{kn + n'}$  expresses

the relation nearest to the consonance  $\frac{m}{n}$ , in which only one coincidence is possible during a second, so that the notes  $km + m'$  and  $kn + n'$  give *one* beat in a second.—We can simplify the relation  $\frac{km + m'}{kn + n'}$  without giving rise to a discrepancy sufficiently great to be taken into consideration in acoustics. If we consider that according to a well-known property of continued fractions,  $nm' - mn' = \pm 1$ ,

$$\text{therefore } m' = \frac{mn' \pm 1}{n}, \text{ then } \frac{km + m'}{kn + n'} = \frac{(kn + n')m \pm 1}{(kn + n')n}$$

$$= \frac{km \pm \frac{1}{n + \frac{n'}{k}}}{kn} = \frac{km \pm \frac{1}{n} \left( \frac{1}{1 + \frac{n'}{kn}} \right)}{kn},$$

and as we may without hesitation make the factor  $\frac{1}{1 + \frac{n'}{kn}} = 1$ ,

$$\frac{km + m'}{kn + n'} = \frac{km \pm \frac{1}{n}}{kn}. \quad \text{In the same manner we might have found}$$

$$\frac{km + m'}{kn + n'} = \frac{km}{kn} \pm \frac{1}{m}, \text{ which proves the fundamental position}$$

above stated. Vincent, moreover, varies the expression of this position as follows: in order to find the number of beats which two notes, that almost form a consonance, yield in a given time, the number of vibrations by which one note deviates from purity, is to be multiplied by the number expressing the other note which is adopted as the standard in the simplest relation of consonance.— Vincent terms this multiplier the *coefficient of consonance*.—It is apparent that the absolute number of vibrations is in this case a matter of no consideration; the essential point being merely the kind of consonance, and the extent of deviation from purity.

Scheibler has by means of the so-called notes of combination of the first and of higher degrees, succeeded in determining the correct relation between the number of vibrations and of the beats for the various consonances; Vincent proves that he has done this, though following a false theory(1), for if in the ratio  $\frac{k m}{k n}$  the numerator be increased by a small value  $\alpha$ , and the greatest common measure of  $\frac{k m + \alpha}{k n}$  be found, we always arrive at a remainder  $r = n \alpha$ , which proves very trifling in comparison of the divisor, which is nearly  $= k$ .—Scheibler has, in reality, done nothing more by his repeated searching after differences and the differences of differences, than has been indicated and invariably occurs in looking for the common measure.

Vincent then gives an exposition of Scheibler's metronome and of his terminology; with the latter he assumes the normal  $\bar{a}$  at 440 complete vibrations, or 880 single vibrations, or 6600 pendulum-degrees; he then solves, in an elegant and concise manner, a series of questions relating to the measurement of notes and to tuning, which are certainly, for the most part, contained in the treatises of Scheibler above quoted, but which are not communicated in a very lucid manner. The following problems may serve as instances:

1) By how many vibrations in a second is it necessary to raise or depress a note of the 12 consonances, in order to afford one beat during this period? How many beats result if the alteration amounts to one vibration? The answer directly results from the above position, and is contained in the following synoptical table:

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(1) Pogg. Ann: XXXII. 494 to 504.

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No.	Kind of consonance.	Relation.	Vibrations more or less for 1 beat.		Beats more or less for 1 vibration.	
			Higher note.	Lower note.	Higher note.	Lower note.
1	Unison . . .	1 : 1	1	1	1	1
2	Octave . . .	2 : 1	1	$\frac{1}{2}$	1	2
3	Double octave .	4 : 1	1	$\frac{1}{4}$	1	4
4	Fifth . . .	3 : 2	$\frac{2}{3}$	$\frac{1}{3}$	2	3
5	Fourth . . .	4 : 3	$\frac{3}{4}$	$\frac{1}{4}$	3	4
6	Major third . .	5 : 4	$\frac{4}{5}$	$\frac{1}{5}$	4	5
7	Minor third . .	6 : 5	$\frac{5}{6}$	$\frac{1}{6}$	5	6
8	Major sixth . .	5 : 3	$\frac{3}{5}$	$\frac{2}{5}$	3	5
9	Minor sixth . .	8 : 5	$\frac{5}{8}$	$\frac{3}{8}$	5	8
10	Twelfth . . .	3 : 1	1	$\frac{1}{3}$	1	3
11	Tenth . . .	5 : 2	$\frac{2}{5}$	$\frac{3}{5}$	2	5
12	Seventeenth . .	5 : 1	1	$\frac{1}{5}$	1	5

2) If we consider  $a = 220$  vibrations, the rising third, fourth, fifth and sixth being given, how much must the latter be altered, in order to give one beat in a second with  $a$ , and how many beats do the notes thus altered afford with the  $a$  of 440 vibrations? The answer is likewise easily deduced from the fundamental position.

If  $\frac{m}{n}$  is a consonance, and  $m$  and  $n$  prime numbers to one another,

and both uneven,  $\frac{m \cdot 2_p}{n}$  and  $\frac{m}{n \cdot 2_p}$  represent the upper and lower octaves; the following is the number of vibrations by which it is necessary to alter a note of these intervals in order to obtain one beat, or the number of beats produced by a vibration more or less :

	Vibrations for 1 beat.		Beats for 1 vibration.	
	Higher note.	Lower note.	Higher note.	Lower note.
$\frac{m}{n}$	$\frac{1}{n}$	$\frac{1}{m}$	$n$	$m$
$\frac{m \cdot 2_p}{n}$	$\frac{1}{n}$	$\frac{1}{m \cdot 2_p}$	$n$	$m \cdot 2_p$
$\frac{m}{n \cdot 2_p}$	$\frac{1}{n \cdot 2_p}$	$\frac{1}{m}$	$n \cdot 2_p$	$m$

With the assumptions made for  $\frac{m}{n}$ , the number of beats or vibrations remains the same for all higher octaves, if the trifling alteration is applied to the higher note, for all the lower octaves if the alteration is applied to the lower note. The number of vibrations on the other hand increases in the relation of the octave, and the number of beats in the inverted ratio, if we pass to lower octaves, but alter the higher note, or to higher octaves, the lower note being altered.

If we apply a small alteration to  $a$ , so that it gives a certain

number of beats with  $\bar{a}$ , or if, as Scheibler expresses himself, we substitute for  $a$  an auxiliary  $a$ , we obtain in the following manner the number of beats which a given note of the tempered scale makes with the auxiliary  $a$ , or the pendulum-number  $X$ , at which a number  $N$  of beats, which is easily observed, corresponds to one vibration.

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beats.

Let  $A$  be the number of vibrations of the auxiliary  $a$ ,  $B$  that of a note of the tempered scale,  $\frac{m}{n}$  the relation of consonance of  $A$  to  $B$ , if  $a$  had not been altered; then  $\left(B - \frac{m}{n}A\right)n$  represents the number of beats in a second, and  $X = \left(B - \frac{m}{n}A\right)n \cdot \frac{60}{N}$  (1) is the pendulum-number sought.

When the normal  $\bar{a}$  makes 420 or 460, instead of 440 vibrations, an alteration occurs in the pendulum-number above calculated. If we look upon the auxiliary  $\bar{a}$  as consisting of two parts, the pure  $a$ , which has half the number of vibrations of  $\bar{a}$ , and the deviation  $\epsilon$  which depends upon the beats, the part  $a$  only is effected in an alteration of  $a$ , and we obtain :

$$\begin{aligned} X &= \left\{ B - \frac{m}{n} (a + \epsilon) \right\} n \frac{60}{N} \text{ for the normal } \bar{a}. \\ (2) \quad X' &= \left\{ B' - \frac{m}{n} (a' + \epsilon) \right\} n \frac{60}{N} \text{ for the deviating } \bar{a}. \end{aligned}$$

If we represent the two  $\bar{a}$  by  $D$  and  $D'$ , then  $B' = B \frac{D'}{D}$ ,  $a' = a \frac{D'}{D}$ , therefore  $X' = -\epsilon \cdot m \frac{60}{N} + \left(X + \epsilon m \frac{60}{N}\right) \frac{D'}{D}$ , or if we assume the difference  $D' - D = d$ ,

$$(3) \quad X' = X + \left(X + \epsilon \cdot m \frac{60}{N}\right) \frac{d}{D}$$

In order to afford by a simple correction a transition from a table calculated from these formulæ, to a similar table in which the auxiliary  $a$  is a little higher or lower, we may employ the equations (2); it will only be necessary to accentuate  $\epsilon$  in the second instead of  $B'$  and  $a'$ , as the alteration will now affect this value. We obtain

$$(4) \quad X' - X = (\epsilon - \epsilon') m \frac{60}{N}.$$

As  $B - \frac{m}{n}a$  is the term for the number of vibrations by which the tempered note deviates from the pure interval, this value may be represented by  $\Delta$ ; we then obtain from the first of the equations (2) and from the equation (3):

$$(5) \quad X' = X + \frac{60}{N} n \Delta \frac{d}{D}$$



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A table being once made out for the values of  $X$ , the formulæ (4) and (5) are chiefly employed in calculating tables for the measurement of notes and for the tuning of instruments. In order to render the formula (5) more easily available, Vincent gives several auxiliary tables, one of which contains the values :

$$\frac{1}{D}, \frac{2}{D} \cdot \cdot \cdot \frac{9}{D} \text{ for } D = 440.$$

The following gives the values of  $\Delta$  for the notes of the tempered scale :

Note.	Accurate interval $\frac{m}{n} \frac{a}{a}$ .	Tempered interval. B.	$\Delta$ .
$\bar{a} = \frac{1}{2} \bar{a}$	440.000	440.000	0.000
$\bar{b} = \frac{1}{15} \bar{a}$ "	469.333	466.164	— 3.169
$\bar{h} = \frac{1}{10} \bar{a}$ "	495.000	493.884	— 1.116
$\bar{c} = \frac{1}{8} \bar{a}$ "	528.000	523.251	— 4.749
$\bar{cis} = \frac{1}{6} \bar{a}$ "	550.000	554.365	+ 4.365
$\bar{d} = \frac{1}{5} \bar{a}$ "	586.667	587.329	+ 0.662
$\bar{es} = \frac{3}{11} \bar{a}$ "	625.778	622.253	— 3.525
$\bar{e} = \frac{1}{4} \bar{a}$ "	660.000	659.255	— 0.745
$\bar{f} = \frac{1}{3} \bar{a}$ "	704.000	698.456	— 5.544
$\bar{fis} = \frac{1}{6} \bar{a}$ "	733.333	739.989	+ 6.656
$\bar{g} = \frac{1}{3} \bar{a}$ "	782.222	783.991	+ 1.769
$\bar{as} = \frac{1}{8} \bar{a}$ "	825.000	830.609	+ 5.609
$\bar{a} = 1$ "	880.000	880.000	0.000

If two notes nearly bear the relation of the consonance  $m : n$ , their exact relation  $\frac{mk}{nk + n}$  is easily ascertained, if in a given time they make a number of beats with one another, which may be easily counted. Let  $b$  represent the number of beats, then  $n' = \pm \frac{b}{m}$  represents the number of vibrations by which the one note  $nk$  deviates from purity.—In most cases, however, the number of beats is not so easily determined, and it will then be necessary to introduce between the notes an auxiliary note, which gives rise to beats with the two given notes that can be counted. Let the relation of the numbers of vibration be approximately expressed by  $m : p : n$ ;  $m$ ,  $n$ , and  $p$  being prime numbers to one another. If  $mk$  gives with  $p$   $k$ ,  $B$  beats in a second, the relation of the numbers of vibrations

will be  $\frac{mk}{pk + \frac{B}{m}}$ ; if the second note gives with the third  $B'$  beats, the relation is expressed by  $\frac{pk + \frac{B}{m}}{nk + \frac{nB}{mp} + \frac{B'}{p}}$ ; and finally,

if the number of beats of the first with the third note be  $b$ , we obtain

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$$\frac{nk + \frac{b}{m}}{nk + \frac{b}{m}} = \frac{mk}{pk + \frac{B}{m}} = \frac{pk + \frac{B}{m}}{nk + \frac{nB}{mp} + \frac{B'}{p}} = \frac{mk}{nk + \frac{nB}{mp} + \frac{B'}{p}}$$

or,  $n' = \frac{b}{m} = n \left( \frac{B}{mp} + \frac{B'}{pn} \right)$ .

In most cases the assumption of  $m$ ,  $n$ , and  $p$  being prime numbers to one another will not be realised, as in order to introduce the note  $p$ ,  $m$  and  $n$  must be frequently multiplied with the same entire number. If  $\alpha$ ,  $\beta$ , and  $\gamma$ , are the common measures of  $m$  and  $p$ ,  $n$  and  $p$ ,  $m$  and  $n$ , the last equation becomes

$$\frac{\gamma b}{m} = n \left( \frac{\alpha B}{mp} + \frac{\beta B'}{np} \right)$$

If it has been necessary to introduce between the two notes  $m$  and  $m^h$ ,  $h-1$  intermediate notes  $m'$ ,  $m''$ ,  $\dots$ ,  $m^{h-1}$ , and if the beats between the two nearest  $B$ ,  $B'$ ,  $B'' \dots$  be measured, the deviation from purity of the note  $m^h$  is expressed by:

$$m^h \left\{ \frac{B \alpha}{m m'} + \frac{B' \beta}{m' m''} + \frac{B'' \gamma}{m'' m'''} + \dots + \frac{B^{h-1} \varpi}{m^{h-1} m^h} \right\}$$

In order to determine the absolute number of vibrations of a note by enumeration of the beats, it is merely necessary to proceed gradatim from the note  $mk$  to another  $m^h k + \epsilon$ , which either yields an exact consonance  $Mk$ , or nearly this consonance  $Mk + \epsilon'$ . This gives

$$m^{(h)} k + \epsilon = Mk + \epsilon' \text{ or } k = \frac{\epsilon - \epsilon'}{M - m^h}$$

For the examples with which Vincent admirably elucidates both theory and practice, and for the manner in which he accounts for the application to organ-tuning, the instrument remaining at the pitch it happens to have, or not, we must refer to the treatise itself.

**Apparatus.**—Sainte-Preuve(1) has proposed to apply the propagation of sound in solid and fluid bodies, to the construction of telegraphs, by uniting the stations by solid rods or tubes filled with a liquid.

**Physiological Acoustics. Velocity of the Sources of Sound and Light.**—Fizeau(2) has delivered a discourse before the Philo-

(1) Instit, 1849, 322.

(2) Ibid. 11.

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mathic Society, on the changes in the pitch of sound or in the colour of light, resulting from the motion of the source of sound or light, or of the observer himself. He calculates the velocities capable of producing a change in the pitch of half or an entire note, or of a third or an octave, and he demonstrates the agreement of the observation with theory, by means of an acoustic apparatus. This consists of a vertical metallic ring, with teeth on its inner circumference, against which an elastic lamella strikes, that is fixed to the circumference of a rapidly rotating wheel. The contact takes place in opposite directions at the highest and lowest points; the velocity may therefore be adjusted in such a manner as to produce the fundamental note below, the octave above, and all intervening notes at intervening points.—Fizeau also calculates the displacement of certain rays in the spectrum, caused by the velocity of Venus or the Earth.

Fizeau might have added that all these observations have several years ago been repeatedly discussed by Doppler, Ballot(1), and others.

According to a communication made to the Academy of Sciences, at Brussels, by Crahay(2), Montigny, in running down a hill, near Namur, imagined that in approaching the town, the bells of the place sounded considerably higher, and much lower as he removed further. In running so as to remain at a uniform distance from the source of sound, or if he held a resonant body in his hand, the pitch remained the same as that which he perceived in the quiescent condition.—We are inclined to think with Crahay, that Montigny must be a great adept at running (to produce an elevation of half a note it is necessary to traverse 16 metres in a second) in order to obtain perceptible differences in pitch in this manner.

**On the Human Voice.**—In our last year's Report(3), we were only able to allude to some detailed communications(4), from which we will now give more copious abstracts. We refer to Segond's treatise on the tone of the human voice. Segond commences by observing that the quality of sound (*timbre*) of a note is determined by the nature of the material which produces it, by the mode of producing the note, by the different handling, and by the character of the media in which the note is formed; he then considers the influence of the various parts of the human organ of voice upon its tone. 1. *Trachea* and *thorax* influence the tone, both by their character determining the rapidity of the current of air and by serving as a sounding apparatus. 2. The *vocal chords* exert an influence as they affect the production of the ordinary and the falsetto notes. If the posterior moveable part of the *rima glottidis* is not entirely closed, the sound

(1) Annual Report for 1847 and 1848, Vol. I, 122.

(2) Instit. 1849, 37.

(3) Annual Report for 1847 and 1848, Vol. I, 123.

(4) Arch. gén. de Médec. Mars. 1848; Jahrb. d. ges. Medicin, LXI, 9.

of the voice changes. Diseases of the larynx have a most decided effect upon the character of the sound.—The chief influence, however, is exerted by the capacity and other qualities of 3. the *tubal prolongation* formed by the *fauces*, the *mouth*, and the *nares*.—The richness in tone of the voice depends upon the dimensions of the gullet, and principally upon the distance between the posterior and anterior pillars of the fauces.—The clear tone of the voice is diminished by raising the root of the tongue; inflammation of the mucous membrane of the fauces deprives the voice of its elegance and purity.—If the larynx is elevated to the utmost, and the mouth opened wide, the voice is screaming. It loses this character in proportion as the mouth is closed, the position of the larynx remaining the same.—If the jaws are much developed, and the mouth small, the voice of the individual sounds muffled; in the reverse case the voice is clear.—If the mouth is closed, so that the voice only issues by the nostrils, it sounds slightly muffled, but not unpleasantly (the first degree of the nasal tone); if the mouth is open as well as the nostrils, and the voice resounds in the posterior nostrils (*choanæ*), and issues by the mouth and nose, the nasal character is then more marked (second degree); the strongest nasal tone (third degree) is produced when the anterior nostrils are closed whilst the mouth is open.—Observations are yet wanting to determine the influences exerted upon the sound of the voice by various states of the organism, by age, race, and climate.—The *inspiratory voice* (1), which is observed in numerous animals, such as the dog, the cat, the horse, the ass, occurs in man in laughing, crying, and sobbing. By dint of practice the whole range of ordinary and falsetto notes of which the expiratory voice is capable may be obtained in inspiration. The character of the notes becomes however, slightly altered, inasmuch as they always appear to come from a greater distance. Segond is of opinion that ventriloquism is entirely produced by the inspiratory voice; still he admits that it is very difficult to emit some consonants, for instance s and r, with this voice.

**The Organ of Voice.**—Physiologists have adopted J. Müller's view, that the two registers of the human voice, ordinary and falsetto notes, are both produced by the inferior vocal chords, according as these vibrate in their entire breadth, or only at the edges that bound the chink.—Segond (2), on the other hand, is of opinion that his observations and experiments prove the ordinary voice to be produced by the lower, the falsetto by the upper vocal chords. All animals that possess the two kinds of voices have the two sets of vocal chords, *e. g.* cats and dogs. He states that if the lower chords are destroyed in a cat, she recovers her mew (her falsetto) in perfect purity as soon as the wound is healed. He adds, that if the mouth of a cat be opened wide, the tongue drawn out, and the epiglottis held open, the upper

(1) Jahrb. d. ges. Medicin, LXI, 11.

(2) Compt. Rend. XXVIII, 538.

The organ  
of voice.

vocal chords may be seen to vibrate ; that if they are divided,\* the mewling ceases. Second obtained the same results in dogs.

**Optics. Sources of Light. Phosphorescence of Living Animals.**  
—Pring(1) has communicated observations on the phosphorescence of a small marine animal, which he believes to be the *Noctiluca miliaris*. The galvanic current increased its brilliancy ; it was more luminous in oxygen and carbonic acid, but it speedily died in the latter. Sulphuretted hydrogen rapidly destroyed the light ; nitrogen, binoxide of nitrogen, and oxygen produced no perceptible effect. Mineral acids increased the brilliancy for a short time, but destroyed it immediately after. Chloroform and ether increased the brilliancy at first, but the animal soon died.

**Theory of Light.**—Cauchy(2) in several communications gives an account of his most recent investigations into the mathematical theory of the motion of the æther ; they claim the interest of physicists in a high degree, on account of their agreement with the experimental results obtained by Jamin. We are constrained to refer to the communications themselves, as such abstracts as our space would permit us to give would be useless.—We merely advert to two points : one is the facility of treatment realised in these complicated investigations by Cauchy, by introducing imaginary variables, which he terms symbolical displacements of the particles of æther, as the real terms indicate the true displacements ; the other is the new principle which Cauchy introduced for the calculation of the phenomena occurring in the transition of a wave from one medium to another, in place of the known hypotheses of Fresnel ; he expresses it in the following terms : the molecular displacements parallel to the co-ordinate axes, and the deductions of these displacements according to the independent variables (at least those of the latter whose values have not been determined by the equations of the infinitely small motions), must in general be *continuous* functions of the variables, *i. e.* they must vary by insensible transitions with the co-ordinates and time. Cauchy states that we arrive at this principle of continuity at once, by assuming that the minute motions of æthereal particles in every medium can be expressed by linear partial differential equations with constant coefficients.—Fresnel's formulæ of reflection can now only be considered applicable to the special case when the third root of the cubic equation, which corresponds(3) to the three commonly occurring wave-trains, is zero for the two adjoining media. Cauchy gives the application of his theory to the colours of thin

(1) Instit. 1849, 326.

(2) Compt. Rend. XXVIII, 2, 25, 57 ; XXIX, 762 ; Instit. 1849, 26.

(3) Annual Report for 1847 and 1848, Vol. I, 126.

layers(1), and directs attention to the special conditions(2) to be introduced into the calculation for crystallised media.—In reference to the latter point, he states that every crystal may be decomposed into a network of congruent cellular spaces by planes which are at equal distances from one another, and parallel to the three rectangular or oblique co-ordinate axes. Each cell-space contains the same molecular group in the same arrangement and distribution, consequently the æther must also be uniformly distributed in all cell-spaces. The equations which express the vibratory motion in an homogeneous crystal, are, therefore, linear equations with periodical coefficients, which are not altered if an advance or retrogression by an entire cell-length be made in the direction of one of the three co-ordinate axes. *In vacuo* the periodical are converted into constant functions. Cauchy gives no opinion on this occasion as to the form assumed by the equations in amorphous transparent media.

Challis(3) has continued his former efforts(4) to deduce the motion of the luminous æther from the fundamental equations of hydrodynamics. In reference to the transit through transparent media, Challis assumes that the æther is of equal density in all, and that the retardation of motion in more powerfully refracting media depends exclusively upon the resistance of the material molecules. This resistance he considers that we may treat as continuous on account of the minuteness of the molecules, and because their sphere of action considerably exceeds their own diameter.—Challis, proceeding upon these principles, finds the surface of elasticity to be an ellipsoid, a result in which he differs from Fresnel. On the other hand, Challis finds the surface whose radius vectors represent the velocity of two rays polarised perpendicularly to one another in the direction of these rays, to be Fresnel's wave-surface. In a subsequent treatise(5) Challis proves that the longitudinal vibrations

in a ray are given by the function  $\sin \frac{2\pi}{\lambda} \left( z - a t \sqrt{1 + \frac{e\lambda^2}{\pi^2}} \right)$ ,  $\lambda$  being the wave-length,  $a$  and  $e$  constants; and that light generally consists of different rays of which  $\lambda$  is unequal, whilst  $a$  and  $\frac{e\lambda^2}{\pi^2}$  are the same; also that light, immediately derived from any given source, is always ordinary light, which is seen in all directions, and is converted into polarised light only by reflection or refraction.

**Velocity of Light.**—Fizeau(6) has succeeded in discovering a

(1) Compt. Rend. XXVIII, 333; Instit. 1849, 98.

(2) Compt. Rend. XXIX, 643, 728.

(3) Phil. Mag. [3] XXXIV, 225.

(4) Annual Report for 1847 and 1848, I, 126.

(5) Phil. Mag. [3] XXXIV, 225.

(6) Compt. Rend. XXIX, 90; Instit. 1849, 233; Arch. Ph. Nat. XI, 308; Pogg. Ann. LXXIX, 167.

Velocity  
of light.

method by which the velocity of light may be measured by terrestrial observations. He erected two telescopes at a distance of 8633 metres from one another; one in a house at Suresne, the other on the Montmartre. They were so turned that they directly faced one another. One of the telescopes was perforated in the vicinity of the focus, and received an intense light from a lamp, which was partially reflected by a piece of transparent plate-glass forming an angle of  $45^\circ$  with the axis of the instrument, in the direction of the other telescope. On reaching this it was reflected by a metallic mirror placed perpendicularly to the axis of the instrument, which was, therefore, seen by the observer at the first telescope as a luminous point.—The edge of a circular disc passed through the field of this telescope, having 720 teeth, and a corresponding number of spaces of the same size, so that during the rotation of the disc the field was alternately obscured by a tooth, or exposed by an interval.—It is evident that if the light require as much time to travel from one station to the other and back, as is necessary to replace an interval by a tooth, the luminous point will continue obscured from the observer at the first telescope, whilst it becomes visible if the velocity of rotation be double, &c. In Fizeau's measurements the first obscuration took place when the disc performed 12.6 revolutions in the second. The mean of 28 observations yielded a velocity of 70948 miles (25 to  $1^\circ$ ) in a second, which is equal to 42569 geographical miles: whereas the most accurate astronomical measurements yield 41518 miles, which is probable within 20 miles of the truth.

**Interference. Powell's Interference-Bands.**—Stokes(1) has directed attention to the mode of rendering available the interference-bands observed and described by Powell(2). Before the retarding plate is immersed, a Fraunhofer's line is made to coincide with one of the vertical wires of a telescope. 1. The variation in the ratio of refraction of the plate is determined from one fixed line to another, if the absolute ratio of refraction is known for one line, by counting the number of bands and estimating the subdivisions which occur between those fixed lines. 2. The absolute coefficient of refraction of the plate for a given line is determined by counting the bands which pass before the wire, if the retarding plate be inclined at a certain angle to the incident light. 3. The alteration in the coefficient of refraction of a fluid for a definite line, caused by an alteration of temperature, is determined by observing the number of bands which passes before the wire of the telescope during the rise and fall of the temperature. It is necessary to measure the changes of temperature with a very delicate thermometer immersed in the fluid. 4. The

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(1) Instit. 1849, 159.

(2) Annual Report for 1847 and 1848, I, 128.

change of the coefficient of refraction for a certain fixed line in the spectrum of a doubly refracting body, occurring with the alteration of the inclination of the ray to the axis of the crystals, is determined by counting the bands, which pass before the wire of the telescope when the crystalline plate is rotated or inclined to a certain extent.—Stokes also discusses the bands in the secondary spectrum of an achromatic prism, as well as the bands first described by Brewster, which are observed when the spectrum is examined through a narrow fissure half covered by a lamina of mica.—It is desirable that the treatise alluded to should be published with more details, as we should then ascertain whether Stokes has himself experimentally tested and proved the methods which he proposes.

\* Interference.  
Powell's interference-bands.

**Interference with Considerable Differences of Route.**—An investigation of Fizeau and Foucault(1) which has been announced several years, on the interference occurring in case of considerable differences of route, to which the reporters of the French Academy paid a high tribute of praise, is now before us(2).

It is well known that when the interfering rays are of a large difference of route, the interference becomes first imperfect, and at last by degrees entirely imperceptible, not only on account of the difficulty of obtaining perfectly homogeneous light, but also because the vibratory condition of the æther gradually changes in the same way, so that if this ray is decomposed into two parts, which again combine with a large difference of route, an interference cannot occur, because the vibrations of the æther-particles do not maintain the same direction. Fizeau and Foucault have, however, demonstrated that if the light be rendered as homogeneous as possible, interferences are still observed, with differences of route of several thousand wave-lengths.

If in a part of space which is illuminated by two white light-pencils of a certain difference of route, a portion be separated by a screen with a fissure, and the light proceeding from this part be passed through a series of prisms consisting of very pure material, we obtain a pure spectrum of the illuminated fissure; in this we observe, if solar light be employed, Fraunhofer's lines, and besides also the dark spaces parallel to those lines, which are owing to the interference of the two pencils of light. Every ray of the spectrum, for which the difference of route of both rays is an uneven multiple of half the wave-length, is extinguished, if the rays are of equal intensity. The more bands will, therefore, be visible the greater the difference of route; they will be closer in the red than in the violet portion, as the latter, by refraction, is more distended in proportion to the diminution of the wave-lengths. The phenomenon presented by the spectrum, if the

(1) Ann. Ch. Phys [3] XXVI, 138; presented to the Academy, Nov. 2, 1845.

(2) Annual Report for 1847 and 1848, 1, 127.



Interference with considerable differences of route.

difference of route of both light-pencils is gradually increased, is thus described by Fizeau and Foucault. Alternate dark and light bands appear at the violet end of the spectrum, gradually traverse the spaces of the different colours, and leave the spectrum at the red end, whilst new series consecutively appear at the blue end. At first broad, so that one band covers the whole spectrum, they gradually become narrower, and are more and more compressed; they become so numerous that Fizeau and Foucault were able to count almost a thousand in the solar spectrum, and to observe even more.

These observers used Fresnel's mirrors as the first source of interference. The middle light fringe alone passing through the fissure yielded, when analysed by the prism, the pure spectrum. If the mirror was then moved parallel to itself, so that fringes of a higher and higher order came before the fissure, the black bands constantly increased. As long as we can count 66 bands between Fraunhofer's lines *E* and *F*, the phenomenon continues distinct; the entire spectrum then has about 500 bands.

We are able to calculate the magnitude of the difference of route of the interfering light-pencils by the number of bands occurring between two rays of a known wave-length. Let  $\lambda$  and  $\lambda'$  be the wave-lengths of two coloured rays, *e. g.* of the lines *E* and *F*, and the difference of route expressed in these wave-lengths  $=n\lambda$  and  $=n'\lambda'$ , then, if  $m$  bands lie between the two coloured rays,  $n' = n - m$ , if  $\lambda'$  is assumed greater than  $\lambda$ . For if, for instance, the difference of route is  $=4\lambda'$  and  $=12\lambda$ , the intervening bands correspond to the wave-lengths which are contained  $\frac{2}{3}$ ,  $\frac{1}{2}$ ,  $\frac{1}{3}$ ,  $\frac{1}{4}$ ,  $\frac{1}{5}$ ,  $\frac{1}{6}$ ,  $\frac{1}{7}$ ,  $\frac{1}{8}$ ,  $\frac{1}{9}$ ,  $\frac{1}{10}$ ,  $\frac{1}{11}$ ,  $\frac{1}{12}$  times in the difference of route. There are, therefore,  $12 - 4 = 8$  bands. But it follows from the

above equations that  $n = \frac{m\lambda'}{\lambda' - \lambda}$ . For the lines *E* and *F*, for instance,

$\frac{\lambda'}{\lambda' - \lambda} = 12.32$ , and as Fizeau and Foucault, while employing the

different interference-fringes, once counted 66, another time 141 bands between those lines, this corresponded to  $n = 813$  wave-lengths of the line *E*, and  $n = 1737$  wave-lengths of the line *F*.

Instead of moving the mirror we may also increase the difference of route by inserting a thin lamina in the path of one ray. The difference of route, and consequently the number of bands, increases with the thickness of the lamina.

A second method employed by Fizeau and Foucault to obtain interferences with great differences of route, consisted in erecting a thin transparent lamina at half the focal distance, behind a cylindrical lens, on which solar light was allowed to fall; a portion of the light converging towards the caustic is reflected at its anterior and posterior surface, and now forms two near caustics before the lens from which the light diverges with a certain difference of route. If a glass plate of 0<sup>mm</sup>·537

thick was employed, the bands between  $F$  and  $G$  were perfectly defined, but too numerous and fine to be counted. The difference of route here amounted to 3406 wave-lengths of the line  $F$  or 3859 wave-lengths of the line  $G$ .—Wrede(1) has produced the same interference-bands in a similar manner incidentally to his ingenious treatise on the absorption of light, which the French physicist might have taken some notice of.

Interference with considerable differences of route.

Lastly, they obtained interferences with a great difference of route by prismatic decomposition of the colours which gypsum-plates of varying thickness give in polarised light; they found, as was to be expected, that the number of bands increases with the order of the colour.—The same experiments had, however, been instituted in 1846 by J. Müller(2) and are generally known from his description; it is therefore unnecessary to enter more fully into the subject at present.

The difference of route in gypsum  $= e \frac{r-r^1}{r^1}$ , if  $e$  represents the thickness of the lamina, and  $r$  and  $r^1$  the refraction of the ordinary and extraordinary rays. This corresponds in reference to the phase which comes into consideration here, to a difference of route in the air  $= e(r-r^1)$ , so that the above quoted number  $n = \frac{e(r-r^1)}{\lambda}$ .  $\Lambda$

lamina of calcareous spar  $54^{\text{mm}}.6$  in thickness, and cut parallel to the axis gave for the line  $F$ ,  $n = 1692$ ; a lamina of rock-crystal cut in the same manner and  $4^{\text{mm}}.79$  thick yielded  $n = 1082$ .

Fizeau and Foucault also point out that with the assistance of the formula  $n = \frac{e(r-r^1)}{\lambda}$  and by the direct observation of  $n$ , the magnitude of the difference  $r-r^1$  may be deduced for the different coloured rays; they consider this determination as peculiarly desirable for a fuller development of the law of dispersion which obtains in the circular polarisation of rock-crystal.—If the thickness of the lamina employed could be continuously reduced down to zero, whilst permanently fixing the place of a dark band in the spectrum, we should observe as many transitions from a minimum of luminosity to a maximum, and *vice versa*, as  $n$  contains units; inasmuch as each time that the difference of route is diminished by an entire  $\lambda$ , a new dark band must occur at the place fixed.

Haidinger(3) has observed, that if the homogeneous flame of a spirit-lamp, containing chloride of sodium, be reflected by a very thin plate of mica with parallel surfaces, the reflected image is traversed by a number of parallel black lines which are vertical to the plane of

(1) Pogg. Ann. XXXIII, 353.

(2) Ibid. LXIX, 98; LXXI, 91.

(3) Ibid. LXXVII, 219; Wien. Acad. Ber. 1849, Febr., 123.

Inter-  
ference  
with con-  
siderable  
differences  
of route.

incidence. The thinner the mica, the broader the bands will be. These bands evidently depend upon the interference of the light reflected at the anterior and posterior surface; and unless the mica, or the lamina of gypsum, which may be used instead, be very thin, the interference-bands belong to a high order; the higher, the nearer the bands are to the eye, as the differences of route of the interfering rays continually increase. The lines can, therefore, only be seen in homogeneous light. Haidinger states, that Ettingshausen has observed that the points of incidence on the mica-lamina, which correspond to equal differences of route of the rays (provided the eye preserve the same position) form a circle, the centre of which is the base of the perpendicular dropt from the eye to the lamina. The eye projects circular lines on the plane, that is perpendicular to the line of vision, in an hyperbola, parabola or ellipse, according as the angle of incidence is greater, equal to, or smaller than  $45^\circ$ . The small portions of this line, however, appeared in the first case in which Haidinger observed them, as straight lines.—Haidinger asserts, that these lines can also be produced by white solar light with a mica-lamina; this is remarkable, and deserves repetition and confirmation.

Haidinger calls to mind the black rings which Talbot obtained with the chloride of sodium-flame in a glass-bubble; they differ from the phenomenon above described in this respect, that their locality is simultaneously determined by the unequal thickness of the medium and the incidence, whilst the latter alone requires to be taken into consideration for the lamina with parallel surfaces.

Haidinger also alludes to an experiment of Wrede(1), consisting in the reflection of light by a cylindrically bent lamina of mica, the light being subsequently decomposed by a prism and examined by a telescope. The spectrum is seen traversed by black lines like those of Fraunhofer. Haidinger appears to have erroneously considered this phenomenon as identical with his own, with the sole exception, that by the cylindrical form of the mica, the picture is converted into a line of light, and that, therefore, the interference-lines are brought very close together, and only become distinctly visible by the telescope after they have been separated by the prism.—In Wrede's experiment the number and arrangement of the lines depend upon the wave-length of the different coloured rays, all of which have the same absolute difference of route; whilst in Haidinger's experiment the lines are produced by rays of equal wave-length, but unequal difference of route.

**Reflection of Light. On Lustre.**—Haidinger(2) has communicated observations on the lustre of bodies. They are important inasmuch as they call upon mineralogists to attend to the physical

(1) Pogg. Ann. XXXIII, 353.

(2) Wien. Acad. Ber. 4 Hft., 137—150.

causes of the various kinds of lustre, especially of glassy lustre, of diamond lustre, and metallic lustre, terms which have generally been looked upon as mere symbols and terms of expression; we cannot, however, characterise Haidinger's explanation as entirely in accordance with our present knowledge of the laws of reflection and polarisation.

Reflec-  
tion of  
light.  
On lustre.

H. Schröder(1), in a treatise entitled "Matt und Glanz," has pointed out, that dull surfaces held between the source of light and the eye, become shaded (owing to the small projections), and that on the contrary, they appear bright if the eye be introduced between the source of light and the surface. The peculiar colour of the body, therefore, which appears to be most intense when it is seen perpendicularly, is mixed in the former instance with grey, in the latter with white.

**Polarisation by Reflection.**—The last Annual Report(2) contains Jamin's discovery, that the elliptical polarisation by reflection of light, which at first was only found in metals, and afterwards in some powerfully refracting media, *e. g.* the diamond, must be considered as the general case; the same observer concludes that physicists have hitherto imagined that they found rectilinear polarisation, as well as an angle of complete polarisation for less powerfully refracting transparent media, merely because the small axes of the elliptical paths travelled by the particles of æther—(when decomposed into the known components, the amplitudes of the vibrations in the plane of incidence)—are too small to be easily perceived. The report made to the French Academy by Cauchy(3) contains some farther data from Jamin's investigations, as well as some interesting remarks by the reporter.—Jamin examined the reflection produced by a large series of substances in the following manner. The incident ray was polarised by a Nicol's prism, so that the direction of vibration formed only a small angle ( $6^\circ$ ) with the plane of incidence, or in other words, that the azimuth of the plane of polarisation amounted almost to  $90^\circ$ . Two quantities must be measured in order to characterise the reflected ray completely. One is the *retardation* which the component in the plane of incidence suffers in comparison to the one that is perpendicular to the plane of incidence; this Jamin determined with the assistance of Babinet's compensator, which in each experiment did away with the difference of phase, and thus restored the rectilinear polarisation. Babinet's compensator consists of two triangular congruent quartz prisms, which are made to slide along one another by means of a micrometer screw; the edges of the first prism are parallel, those of the second, vertical to the optic axis of the rock-crystal. The second quantity is the *ratio of the intensities* of both components; this

(1) Pogg. Ann. LXXVIII, 569.

(2) Annual Report for 1847 and 1848, Vol. I, 131.

(3) Compt. Rend. XXVIII, 120; Instit. 1849, 34.

Polarisation by reflection.

was deduced from the azimuth of the resulting rectilinear vibration, which was sought by means of a second Nicol's prism.

There were only two substances, menilite and alum, in which Jamin found an angle of complete polarisation. As at this limit for increasing angles of incidence the difference of phase passes from  $\pi$  to  $2\pi$ , a transition which cannot take place suddenly, it is evident that the period of transition in this case is so short as not to be perceptible.—In three substances, Jamin curiously enough found negative differences of phase, namely in opal, hyalite and fluor-spar whose coefficients of refraction are all near to 1.43.

Cauchy has based his doctrine of reflection upon the fundamental laws of molecular mechanics, and especially upon the law of a continuous motion of the æther (see page 65), and not upon Fresnel's hypotheses; he has thus found that the difference of phase of the two components of the reflected ray, if reduced by  $\tau$ , is nearly equal to the sum of two positive angles  $\phi + \phi'$ , the tangents of which are given by

$$\operatorname{tg} \phi = \epsilon \sin \tau \operatorname{tg} (\tau + \tau'), \text{ and } \operatorname{tg} \phi' = \epsilon \sin \tau \operatorname{tg} (\tau - \tau')$$

in which  $\tau$  represents the angle of incidence,  $\tau'$  the angle of refraction and  $\epsilon$ , what Jamin termed the coefficient of ellipticity.

Assuming  $k = \frac{2\pi}{\lambda}$ , in which formula  $\lambda$  represents the wave-length of the incident ray, we obtain

$$\epsilon = \frac{k}{k''} - \frac{k}{k_{,,}}$$

where  $k''$  and  $k_{,,}$  are, what Cauchy termed the coefficients of extinction of the extinct (third) ray (1) in the reflecting body and the air.—It is only when both coefficients are equal that  $\epsilon$  becomes zero, and the polarisation rectilinear, as in menilite and alum. Cauchy had formerly assumed the coefficient  $k_{,,}$  as infinitely great; but although it may have a very high value, still this must be finite, as  $\epsilon$  could not otherwise become negative, which does occur as Jamin has noticed in a few examples.

If a ray does not pass from the atmosphere but from one denser refracting medium into another, the polarisation of the light reflected at the boundary-plane, invariably becomes rectilinear if the coefficients of extinction are equal in both media. This remark of Cauchy's points to a new field of experimental research.

**Nature of Polarised Light.**—A rational mode of treating the phenomena of polarisation necessarily pre-supposes a distinct knowledge of the direction in which the vibrations of the æther-particles occur in the polarised ray. The fundamental phenomena of polarisation, the phenomena at the second mirror of polarisation, as well as the property of tourmaline to be opaque, even in very thin laminæ, when

cut perpendicularly to the axis, when contrasted with the deportment of the laminæ cut parallel to the axis, should convince every unprejudiced person that the vibrations occur perpendicularly to the plane of polarisation, or in the light polarised by reflection, *perpendicularly to the plane of incidence*; still contradiction and confusion has hitherto prevailed on this subject in optical treatises and manuals. It is therefore gratifying that Cauchy has now used the first of the two mentioned phenomena, in order to base the fact that the vibrations take place perpendicularly to the plane of polarisation on a simple proof (1) which is accessible to everybody.

He says: If a ray of polarised light be thrown upon the boundary plane of two isophanous media (the vibrations of which ray are parallel to that plane, and therefore transverse) there can only be transverse vibrations in the reflected and refracted ray. But as the reflected ray could only disappear if the coefficients of refraction of both media were equal, it follows that a ray, the vibrations of which move parallel to the reflecting surface, cannot be made to disappear by reflection. But as it is customary to say of a ray which cannot thus be extinguished, that *it is polarised in the plane of incidence*, it follows that the vibrations occur perpendicularly to the plane of polarisation.

We are led to believe that now that the mechanics of polarisation have received a firm basis by Cauchy's and Jamin's labours, it is time to give up altogether the clumsy term plane of polarisation in the description of the phenomena, and only to speak of the direction of vibration.

In opposition to this view, Babinet(2) promises to prove that the vibrations take place *in* the plane of polarisation. He arrives at this conclusion by the two following experiments. 1. If a sheet of white paper is perpendicularly illuminated by solar light, the polariscope discovers polarised rays, which pass above and below the surface of the paper parallel to it, and whose plane of polarisation coincides with the surface of the paper. 2. The same is observed, if instead of the paper, a white-hot metallic surface is employed. We may assume that Babinet will not succeed in establishing his proof.

**Newton's Coloured Rings.**—Newton thought he had discovered that the thicknesses of the layer of air between two glass lenses, which correspond to the same ring at different incidences, change proportionally to the secant of an angle  $u$  which is given by the equation  $\sin u \frac{106n+1}{107n} \sin r$ ,  $n$  being the index of refraction of the glass, and  $r$  the angle of incidence of the refracted ray within the thin layer. According to the undulatory theory the thicknesses

(1) Compt. Rend. XXIX, 645.

(2) Compt. Rend. XXIX, 514; Instit. 1849, 361; Pogg. Ann. LXXVIII, 580; Arch. Ph. Nat. XII, 313.

New-  
ton's  
coloured  
rings.

for all incidences should be proportional to  $\sec. r$ ; the above value corresponds with this sufficiently up to  $r = 60^\circ$ . In order to explain the deviation for higher values of  $r$ , Herschel assumed that Snellius' law of refraction was not absolutely correct for great incidences, whereas Radicke(1), instead of adopting this very objectionable hypothesis, explains it by stating that the point at which the rays strike the upper surface is not sufficiently approximated to the point of exit, that the thicknesses traversed forwards and backwards can be looked upon as equal.

Provostaye and Desains(2) have recently discovered that, contrary to the assertion of Newton, the theoretical law perfectly agrees with the observations up to the last limit at which the rings are distinctly visible. The flame of an Argand lamp, and without a glass chimney, was used as source of light; it was fed with alcohol containing chloride of sodium. The rings presented the most beautiful and quiet appearance if the rays were allowed to pass through a sheet of white oiled paper. If the angles of incidence are very great, the rings disappear in the quantity of light reflected at the first surface of the upper glass, and they are only seen, if the apparatus is half shaded, at the boundary of light and shade.—For the production of the rings they employed a polished glass plate and a plano-convex lens, which being placed perfectly horizontally could by means of the micrometer-screw of a straight-line engine, be moved horizontally so far that the vertical wire of a theodolite, directed for each incidence, had been tangential to the rings in the two terminal points of the same diameter.—The lower glass plane was set horizontally by means of levels and screws; the horizontal position of the plano-convex lens was determinable with great accuracy, as the diameter of the rings was necessarily altered on the apparatus being rotated on a vertical axis as long as an inclination to the horizon existed. Two series of experiments made at an incidence of  $17^\circ 37'$  and  $61^\circ 37'$ , with a lens of  $13^m.29$  radius, and continued to the 43rd and respectively 24th ring (the dark centre spot being always counted as the first ring) yielded results exhibiting a complete agreement between observation and calculation; the deviations extended at most to  $0^{mm}.12$ . The same series continued to the 67th and respectively 32nd ring certainly yielded deviations of more than  $1^{mm}$ , but Provostaye and Desains remark that an almost vanishing deviation from the spherical form sufficiently accounts for that irregularity, and that we can but admire the art which succeeds in obtaining the globular form with so much accuracy.—Provostaye and Desains have shown clearly by two series of experiments the great influence of

(1) Handbuch d. Optik, II, 63.

(2) Ann. Ch. Phys. [3] XXVII, 423; Compt. Rend. XXVIII, 253, (in abstr.); Instit. 1849, 57; Pogg. Ann. LXXVI, 459.

the most trifling change of form. In one series the lens was not in complete contact with the glass plane, in the second it was too strongly pressed upon it. In the latter instance the diameters increased considerably.

Newton's  
coloured  
rings.

Three series of experiments were instituted which determined the main question; the two first were made with a lens of from 37 to 38 meters radius, the second with another lens of nearly the same curvature at the incidences of  $7^{\circ}55'$ ,  $37^{\circ}36'$ ,  $61^{\circ}37'$ ,  $74^{\circ}17'$ ,  $80^{\circ}39'5$ ,  $80^{\circ}46'$ ,  $84^{\circ}3'$ ,  $85^{\circ}21'$ ; the third series even of  $86^{\circ}14'$ ; it resulted that the diameters increase with the greatest accuracy up to the greatest incidences according to the formula

$$D^2 = 2(m-1)k \sec. r,$$

in which  $m$  represents the number of the ring,  $r$  the inclination,  $k$  a constant equal to the product of the diameter of the globe from which the lens is cut, into the wave-length of the light employed. The accordance between theory and observation is thus established.

**Central Spot of Newton's Rings.**—Newton's rings which are formed between two lenses lying upon one another, disappear if the angle of incidence is so great that total reflection occurs at the posterior surface of the upper lens; however, the central dark spot remains. — By a suitable interpretation of Fresnel's formulæ of intensity, which become imaginary when the limit of complete reflection is overstepped, Stokes(1) has deduced the intensity of reflected light for this case also, and, consequently, for greater incidences. The intensity of the incident ray, polarised *in the plane of incidence* taken as unit, we obtain for the reflected ray

$$J = \frac{(1 - q^2)^2}{(1 - q^2)^2 + 4 q^2 \sin^2 2\vartheta}, \text{ in which } q = \epsilon - \frac{2\pi D}{\lambda} \sqrt{\mu^2 \sin^2 i - 1};$$

$\mu$  is the coefficient of refraction of the first medium,  $i$  the angle of incidence at the surface of the second medium, *i. e.* of the layer of air,  $D$  the thickness of the layer at the point under consideration,  $\lambda$  the wave-length,  $2\vartheta$  the acceleration of the phase in total reflection. The latter magnitude alone varies, in calculating the intensity of the light polarised perpendicularly to the plane of incidence. Stokes has deduced several corollaries from his formula, and he has found them all most accurately confirmed by experiment.

**Simple Refraction. Determination of the Coefficients of Refraction.**—The Duc de Chaulnes(2) has been the first to employ the microscope for determining the coefficient of refraction for thin plates; the changes in the position of the microscope necessary to see successively the upper and lower plane of the lamina, were

(1) Phil. Mag. [3] XXXIV, 137.

(2) Mem. de l'Acad. 1767.



Simple  
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refraction.

measured by means of a micrometer-screw. Brewster has applied the same method to fluids, and E. Becquerel and Cahours(1) have shown that we can do without the micrometer-screw in these measurements, if instead of the change of position, we measure how much a glass micrometer is magnified when air first, and then successively the fluids which are to be examined for their refracting power, are introduced between it and the object-glass.

Bertin(2) has again altered the method, which serves him as well for laminae of solid bodies as for fluids; he makes the eye-glass of the microscope moveable, and upon an operculum which he places on the stand he lays the lamina to be examined, and upon this again a glass micrometer with the division downwards. After measuring the enlargement  $G$  of the micrometer, the latter is placed under the lamina to be examined. The eye-piece now requires to be pushed in, in order to render vision distinct again, and the latter lower degree of enlargement  $\gamma$  is now measured; finally the lamina is removed, the eye-piece pushed in still farther, and the enlargement  $g$  measured, which again is rather less than before.—Bertin measured the enlargement with a pair of compasses, which he directed to two definite lines of division of the micrometer with one eye, and which he saw with the other by the microscope. A more convenient mode of measurement would probably be obtained by employing two wires in the focus of the eye-piece; the ordinary achromatic eye-pieces used in the microscope are not, however, applicable to the purpose. (See Optical Instruments).

If an object lies at the distance  $p$  before the object-glass, and its image at the distance  $p'$  behind it, then  $\frac{1}{p} + \frac{1}{p'} = \frac{1}{f}$ , and as the enlargement by means of the object-glass is  $\frac{p'}{p}$ , this equation can be written  $1 + \frac{1}{G} + \frac{p}{f}$ . In the above three measurements the distance of the micrometer from the object-glass is successively  $p$ ,  $p + \epsilon$ , and  $p + e$ , we thus obtain the three equations,

$$1 + \frac{1}{G} = \frac{p}{f}; 1 + \frac{1}{\gamma} = \frac{p + \epsilon}{f}; 1 + \frac{1}{g} = \frac{p + e}{f};$$

and as a very simple construction gives  $\frac{e}{\epsilon} = n$ , or equal to the coefficient of refraction, we obtain by elimination of  $p$  and  $f$  in the above equations,

$$n = \frac{\gamma (G - g)}{g (G - \gamma)}$$

If the lamina is very thick, then  $\gamma$  and  $g$  are so small, and differ so

(1) Pogg. Ann. LI, 427; Compt. Rend. XI, 867.

(2) Ann. Ch. Phys. [3] XXVI, 288; Compt. Rend. XXVIII, 447 (in abstr.); Instit. 1849, 105; Pogg. Ann. LXXVI, 611.

little,\* that it is preferable to compare them with another lamina of known thickness and known coefficient of refraction. From the preceding equations, as  $e - \epsilon = e \left(1 - \frac{1}{n}\right)$ , we arrive at

$$\frac{e n' (n - 1)}{e' n (n' - 1)} = \frac{\gamma' (\gamma - g)}{\gamma (\gamma' - g)}$$

Simple refraction.

Determination of the coefficients of refraction.

where  $e$  and  $e'$  represent the thicknesses, and  $n$  and  $n'$  the coefficients of refraction of the two laminæ.

If we wish to apply the method to liquids, Bertin directs the employment of short cylindrical pieces of tubes, covered at both ends with flat opercula, which are provided on their inner surface with micrometric divisions. Whilst the vessel is empty, the enlargement  $G$  of the upper, and  $g$  of the inferior micrometer is measured, the liquid then introduced, and the enlargement  $\gamma$  of the lower micrometer again measured. We then again obtain  $n = \frac{\gamma (G - g)}{g (G - \gamma)}$ .

Finally Bertin gives another formula for Brewster's method of measuring the index of refraction of liquids by means of a plano-concave lens introduced between the object-glass and the stand; it is a formula in which the distances of the micrometer from the object-glass are replaced by the enlargements which can be measured without the micrometer-screw, which generally is wanting in the microscope. We may state that the formula is nearly identical with the one given by E. Becquerel and Cahours. (See p. 76)

It is necessary to guard against attributing too great importance to the multiplication or improvement of the methods intended for the approximate determination of mean coefficients of refraction, as in practical optics and molecular physics no question is determinable by such approximate values.

Dutirou(1) has measured the coefficients of refraction of 18 varieties of glass according to Rudberg's method. The numbers of the following table apply to the following glasses: 1) heavy yellow boracic acid-flint-glass from the factory of Mr. Feil; 2) Frauenhofer's flint-glass; 3) Bontemp's flint-glass, quite pure, but strongly hygrometric; 4) Guinand's common flint-glass; 5) Guinand's flint-glass with boracic acid; 6) another variety of the same; 7) Guinand's old white flint-glass; 8) Guinand's crown-glass with boracic acid; 9) the same; 10) Guinand's common crown-glass; 11) Venetian glass, very dry; 12) Guinand's crown-glass with boracic acid (new and of superior quality); 13) Dollond's crown-glass; 14) boracic acid-glass with a new basis, by Messieurs Mäes and Clémandot in

(1) Compt. Rend. XXIX, 632; in detail, with description of the apparatus and the method, Ann. Ch. Phys. [3] XXVIII, 176; the results corrected, Ann. Ch. Phys. [3] XXVIII, 501.

Simple  
refrac-  
tion.

Determi-  
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refraction.

Clichy; 15) Bontemp's crown-glass (ill-adapted for optical purposes); 16) the same as 14; 17) the same; 18) glass from St. Gobin.

No.	Density.	Density measured at	Temp. during the measurement of refraction.	Refracting Angle.	$n_h$	$n_g$	$n_f$	$n_e$	$n_d$	$n_c$	$n_b$
1.	3.417	10.0	19.0	35° 15' 2"	1.76369	1.74859	1.73197	1.72339	1.71439	1.70700	1.70492
2.	2.135	8.75	14.25	36 24 50	1.66788	1.65729	1.64536	1.63913	1.63238	1.62722	1.63142
3.	2.011	8.75	18.25	35 5 22	1.65580	1.64573	1.63458	1.62847	1.62222	1.61720	1.61541
4.	3.610	10.0	16.0	39 50 30	1.65421	1.64432	1.63314	1.62730	1.62090	1.61605	1.61440
5.	4.322	10.0	15.0	60 5 50	1.65391	1.64389	1.63276	1.62696	1.62055	1.61580	1.61402
6.	3.559	10.0	16.0	39 57 37	1.64964	1.64008	1.62917	1.62349	1.61715	1.61242	1.61071
7.	2.622	10.0	18.5	60 0 52	1.64906	1.63913	1.62800	1.62227	1.61598	1.61125	1.60950
8.	2.642	10.0	15.5	60 37 56	1.55600	1.55180	1.54584	1.54270	1.53910	1.53617	1.53519
9.	2.618	10.0	14.0	60 1 44	1.55389	1.54902	1.54324	1.54002	1.53635	1.53337	1.53264
10.	2.184	8.5	17.5	39 55 40	1.54855	1.54387	1.53825	1.53500	1.53173	1.52904	1.52805
11.	2.713	9.7	18.0	59 58 45	1.54805	1.54327	1.53754	1.53445	1.53089	1.52837	1.52727
12.	2.362	9.0	16.0	60 0 53	1.54778	1.54304	1.53743	1.53455	1.53110	1.52849	1.52746
13.	2.484	10.0	11.5	59 57 32	1.54442	1.53927	1.53409	1.53113	1.52773	1.52469	1.52400
14.	2.835	9.5	15.0	35 29 50	1.54660(1)	1.53251	1.52706	1.52401	1.52072	—	—
15.	2.447	10.0	16.0	60 7 30	1.53224	1.52754	1.52216	1.51921	1.51596	1.51338	1.51244
16.	1.951	8.5	17.25	35 34 22	1.53137	1.52704	1.52192	1.51900	1.51582	1.51330	1.51220
17.	1.523	8.5	17.5	34 55 14	1.53107	1.52671	1.52142	1.51863	1.51565	1.51216	1.51183
18.	2.329	8.5	19.25	59 34 22	1.52073	1.46238	1.45557	1.45290	1.44979	1.44711	1.44600

(1) Probably intended to be 1.53600.

Forbes(1) has measured the ratio of refraction of pure chloroform of a sp. gr. 1.4966. The prism had a temperature of probably 12°·2, and a refracting angle of 39° 41'. He found

For the extreme Red  $n = 1.4475$   
*B* in the Red . . . = 1.4488  
*D* in the Orange . . = 1.451  
*b* in the Green . . . = 1.456

*F* in the Blue . . .  $n = 1.457$   
*H* in the Violet (the least  
 refrangible line) = 1.463  
 Extreme Violet . . = 1.4675

The dispersive power  $\frac{dn}{n-1} = 0.045$  is almost identical with that of the ethereal oils.

**Longitudinal Bands in the Solar Spectrum.**—Wartmann(2) has lately, in reference to the longitudinal bands in the solar spectrum, given his adhesion to the opinion of Knoblauch and Karsten, Kuhn and Crahay, which has also been confirmed by Cavalleri in Monza(3), namely, that those bands are produced by irregularities at the edges of the fissure and the mirror, and by the impurity of the atmosphere. Zantedeschi(4) also again reverts to the subject(5). He admits that some lines are produced by imperfections of the appa-

(1) Phil. Mag. [3] XXXV, 94.

(2) Arch. Ph. Nat. X, 303.

(3) Ibid. 303, from Diario ed Atti dell' Accademia Fisico-medico-statistica di Milano, Nr. 13 et 17.

(4) Arch. Phys. Nat. XII, 43.

(5) See Annual Report for 1847 and 1848, Vol. I, 153.

ratus. Others again are said to originate in the vesicular vapour in the atmosphere, and to be moveable. Others again are said to be due to interference and inflection.

Longitudinal bands in the solar spectrum

**Nomenclature of Colours.**—Forbes(1), induced as it appears by the contemplation of the extremely numerous shades of colour contained in the collection of the mosaic manufactory established for the adornment of St. Peter's in Rome, has proposed a classification and nomenclature of the colours. In the history of the subject he first cursorily alludes to Pliny's statements, and then passing to the doctrines of Newton, gives his well-known law of colours(2). He dwells upon the difference between the mixed colours obtained by illuminating a white screen with various prismatic rays, or by mixing pigments; in the former mixed colours, the sum of luminosity prevails; in the latter, in the most favourable case, only the mean of the luminosity of both mixed pigments, so that the latter always appear more dull, or as if mixed with grey. If, for instance, we wish to apply red, yellow, and blue, in sectors to a disc, so that the disc shows white when rotated, Newton's law of colours gives the breadth of the sectors  $r : y : b = 0.386 : 0.196 : 0.418$ . But according to Lambert's experience, red pigment reflects in the most favourable case only  $\frac{1}{3}$ , yellow only  $\frac{1}{10}$ , blue only  $\frac{1}{7}$  of the incident rays; it is therefore necessary, if we wish to have white in the reflected light, to apply the sectors in the ratio  $3r : 2.5y : 7b = 1.157 : 0.490 : 2.927 = R : Y : B$ . Accordingly of all the incident red rays therefore only  $\frac{1}{3} \cdot \frac{R}{R+Y+B} = \frac{1}{3} \cdot \frac{R}{S} = \frac{r}{s}$  are reflected, of the yellow rays  $\frac{y}{s}$ , of the blue  $\frac{b}{s}$ . Consequently we obtain white light, the intensity of which is attenuated  $s$  fold, or 4.574 times; whereas, if we allow white light to fall on a white disc, the intensity of the reflected red-light is only 2.5 times less, according to Lambert. The grey colour which the rotating disc that is covered with pigments shows instead of white is thus explained.

Forbes then proceeds to describe and criticise Mayer's triangle(3), and Lambert's pyramid of colours(4) (he appears unacquainted with Runge's(5) globe of colours), and quotes the well-known views of Wollaston, Young, and Nollet, and finally those of Brewster, on the true fundamental colours of the spectrum. He then quotes a treatise by Hay, on the nomenclature of colours, which is but little known in Germany. Hay assumes red, yellow, and blue as primary

(1) Phil. Mag. [3] XXXIV, 161.

(2) Newton, Optice, Lib. I, pars II, propos. VI, probl. 2; Wilde's Gesch. der Opt. II, 33.

(3) De affinitate color. in Tob. Mayer opp. ined. I, cura Lichtenb. 1775.

(4) Beschreibung einer ausgemalten Farbenpyramide, Berlin 1772.

(5) Farbenkugel, Hamburg 1810.

Nomen-  
clature of  
colours.

colours, and deduces from them as secondary colours, orange, green, and purple. By combination of the secondary, the tertiary colours, &c. are formed as follows,

Red $r_8$	}	Orange $r_4 y_4$	}	Citrine $y_4 b_3 r_2$	}	Green hue $y_8 b_3 r_2$
Yellow $y_8$		Green $y_4 b_4$		Olive $b_4 r_3 y_2$		Purple hue $b_3 r_3 y_2$
Blue $b_3$	}	Purple $b_4 r_4$	}	Russet $r_4 y_2 b_2$	}	Orange hue $r_3 y_3 b_2$
Red $r_8$		Orange $r_4 y_4$		Citrine $y_4 b_3 r_2$		
Yellow $y_8$						

These colours are also to be found in Mayer's triangle, thus the green hue  $y_3 b_3 r_2$ , for instance, may be looked upon as composed of 2 green and 6 grey,  $y_1 b_1 + y_2 b_2 r_2$ , and has its place on the line which unites the middle of the triangle with the middle of the side yellow—blue, taken at a distance of  $\frac{1}{4}$  from the middle of the triangle.—All the combinations of three primary colours may be considered as transitions from a primary or secondary colour to grey. Forbes now proposes the following classification of colours, in which the colours belonging to the places marked + (their complete name, *e. g.* greyish-orangish-red, is easily supplied) are said to suffice completely for the indication of the shades. By mixing these colours with black or white, a series of corresponding colours are deducible, which Forbes, following Hay, calls tints and shades of colour.

Red.	Greyish-red	Grey-red	Red-grey	Reddish-grey	Grey
Orangish-red .	+	+	(Russet)		
Orange-red .					
Red-orangish .	+	+	+		
Reddish-orangish .	+	+			
Orange.	Greyish-orange	Grey-orange	Orange-grey	Orangish-grey	Grey
Yellowish-orange	+	+	(Brown)		
Yellow-orange	+	+	+		
Orange-yellow					
Orangish-yellow	+	+			
Yellow.	Greyish-yellow	Greyish-yellow	Yellow-grey	Yellowish-grey	Grey
&c.		(Citrine)			
.....					
Green.	Greyish-green	Grey-green	Green-grey	Greenish-grey	Grey
		(Drab)			
.....					
Blue.	Greyish-blue	Grey-blue	Blue-grey	Bluish-grey	Grey
		(Olive-coloured)			
.....					
Purple.	Greyish-purple	Grey-purple	Purple-grey	Purple-grey	Grey
Reddish-purple	+	+			
Red-purple .	+	+	+		
Purple-red .					
Purplish-red .	+	+			
Red.	Greyish-red	Grey-red	Red-grey	Reddish-grey	Grey

**Double Refraction. Constants of Polarisation and Double Refraction in Quartz.**—In order to explain the optical phenomena presented by quartz, Airy assumed that every ray entering it is decomposed into two elliptically polarised rays of opposite rotation and unequal velocity of propagation. The polarisation is rendered circular or rectilinear according as the rays emerge parallel or perpendicular to the axis.—Jamin(1) has undertaken to measure the dependance of the relation of the velocities of propagation as well as of the axes of the ellipses upon the incidence of both rays. He allowed light to enter, which was polarised in the principal section, and measured the relation of the amplitudes as well as the difference of phases of the two emerging components, one of which was polarised in the principal section, the other perpendicularly to the principal section. The magnitudes sought as above-mentioned are easily calculated by those measured. The relation of the ellipse-axes diminishes with increasing incidences very rapidly from 1 to zero, Jamin found,

Double  
refrac-  
tion.

Constant  
of polar-  
isation and  
double  
refraction  
in quartz.

Angle of Incidence calculated from the Axis.	2	5° 17'	9° 15'	15° 28'	19° 42'	24° 30'
Relation of the Axes of the Ellipse.	0.939	0.641	0.309	0.125	0.087	0.052

The difference of route of the two elliptical rays is proportional to the thickness of the quartz-layer traversed. In the case of the angle of incidence being above 30°, it follows the law of Huyghens.—The following numbers give the difference of route caused by a lamina of 1<sup>mm</sup> in thickness expressed in parts of the wave-length :

Angle of Incidence.	0°	5° 25'	11° 8'	15° 33'	20° 27'	25° 17'	30° 26'	35° 3'
Difference of Route.	0.120	0.135	0.273	0.490	0.819	1.231	1.774	2.287

**Phenomena of Colours in Doubly-Refracting Bodies. Luminous Rings in Calcareous Spar and Beryll.**—Brewster has several times(2) directed attention to the small cavities which occur in certain calc-spars, berylls and topazes, and which are filled with two liquids that do not mix; the layer surrounding the cavity must have been condensed by their power of expansion at the time the crystal was in a liquid state, and thus the power of refracting light has been modified at these points. Brewster has lately described an optical phenomenon(3) consisting of several luminous rings, which owes its origin to the above-mentioned cavities, and when produced in a dark room, with the aid of solar light, is said to be one of the finest optical phenomena. Brewster has found the phenomenon most beautiful in calc-spar, less so in beryll. In sapphire which contains three systems of cavities parallel to the sides of an equilateral triangle, the three systems of luminous lines afford on reflection the hexagonal radiation which has been so much admired. The

(1) Instit. 1849, 91.

(2) Edinb. Transact. 1823, X, 1. 407; see Annual Report for 1847 and 1848, Vol. I, 158.

(3) Phil. Mag. [3] XXXIII, 489; Instit. 1849, 79.

Irides-  
cence of  
surface  
in doubly-  
refracting  
crystals.

lines are converted into rings if the sapphire is cut in the direction of planes which are not parallel to any of the three systems. As we have not had an opportunity of seeing the phenomenon presented by calcareous spar, we refer to the treatise itself for particulars.

**Iridescence of Surface in Doubly-Refracting Crystals.**—Babinet(1) found that the law, according to which the ray that is more powerfully refracted suffers greater absorption, is confirmed by a great number of coloured doubly-refracting crystals. Haidinger(2) points out a connection between this absorption and the iridescence at the surface presented by the light reflected by many crystals. This iridescence of surface, when examined in chrysolepate of potassa, aloëate of potassa, croconate of copper and platinate of ammonia, with the aid of a dichroscopic lens exhibited not only the same state of polarisation as the most refracted (and therefore most absorbed) ray, but also its complementary colour.

**Pleochroism and Iridescence of Surface.**—Haidinger(3) gives the following remarks on the pleochroism of the oxalate of sesquioxide of chromium and potassa. The light vibrating in the direction of the normal (supplementary line) and the transverse axis (perpendicular) appeared by the dichroscopic lens as varying between the green of seladon and of leek, with a slight tinge of violet; for the second it was rather more yellowish-green, and lighter. The colour vibrating along the axis (middle line) is Berlin blue, and has the lightest hue. According to Bussy and Berlin, the powder of the crystals is green; as the colours invariably become lighter when a substance is powdered, we find that the lighter blue disappears entirely in this case, and the green remains.—The colour of the solution passes, according to the various degrees of saturation, from a mere seladon-green to the darkest columbine-red.

Haidinger thus characterises the pleochroism of hypersthene(4):

- |                                     |                         |                  |          |
|-------------------------------------|-------------------------|------------------|----------|
| 1. Axis (middle line).              | Grey, in part greenish, | darkest          | } Hue.   |
| 2. Transverse Axis (perpendicular). | Hyacinth-red            | { more reddish   |          |
| 3. Normal (supplementary line).     | Reddish-brown           | { more yellowish |          |
|                                     |                         |                  | lightest |

The red iridescence was examined by means of the dichroscopic lens. In the longitudinal position of the crystal *O* appeared reddish and lustrous, *E* lustreless and grey, whereas in the transverse position *O* was bright and *E* red.

A variety of chrysoberyl described under the name of *Alexandrite*, and derived from the Ural, is represented by Haidinger(5) as possessing the following optical relations,

(1) Pogg. Ann. XLVI, 478.

(2) Pogg. Ann. LXXVI, 99.

(3) Pogg. Ann. LXXXVI, 107.

(4) Pogg. Ann. LXXXVI, 294; Wien. Acad. Ber. 4. Heft, 3.

(5) Pogg. Ann. LXXXVII, 228.

## In grey-white nebular light,

1. In the direction of the	Longer Diagonal of the Base	Olive-green	Lightest hue.
2.       "       "	Principal Axis	Verdigris	Darkest hue.
3.       "       "	Shorter Diagonal of the Basis	Seladon-green	Middle hue.

## In perfectly white light,

1. Orange-yellow	Lightest hue.
2. Pure Emerald-green	Darkest hue.
3. Columbine-red	Middle hue.

The colour appertaining to the diagonal of the basis, is itself what is termed dichromatic. It contains two maxima of colour: in thinner crystals it is green, with an admixture of violet; in thicker crystals the reddish-violet, or columbine-red, alone remains.—The solutions of sesquichloride of chromium, of alum, as well as of Gregory's oxalate of sesquioxide of chromium and potassa, and also the crystals of the last salt, present the same colour.—With candle light colour No. 1 appears reddish, No. 3 pale-red, No. 2 remains unchanged a beautiful green.

According to Soret(1), the optic axes of chrysoberyl form an angle of  $27^{\circ} 51'$ , the middle line unites the edges of the prism of  $119^{\circ} 46'$ . The darkest hue is found in the middle line, the middle hue is in the supplementary line, and the lightest hue in the normal line.

According to Biot and Brewster, the crystal is attractive or positive, whence the fact of the middle line possessing the darkest hue, entirely accords with the remark of Babinet above quoted(2).

**Optical Properties of Antigorite.**—Haidinger(3) found *Antigorite* a mineral of a thin slaty structure, resembling serpentine in its composition, on examination with the dichroscopic lens to be *dichromatic*. By the manner in which it polarises light he recognised it as a mineral belonging to the Regular system of crystallisation, and optically binaxial. He estimates the apparent angle of the optic axes at  $35^{\circ}$ , so that if the coefficient of refraction be assumed at 1.55, the true angle of the optic axes must be about  $22^{\circ}$ .

Haidinger also communicates some observations on the optical characters of platino-cyanide of magnesium(4).

**Circular Polarisation by Liquids.**—For a series of years Biot(5) has made the phenomena of circular polarisation by liquids the subject of a careful investigation. The application of the

(1) Recherches sur la position des axes de double réfraction dans les substances cristallines. Genève, 1821.

(2) Comp. p. 82.

(3) Pogg. Ann. LXXVII, 94; Wien. Acad. Ber. 3. Hft.

(4) Pogg. Ann. LXXVII, 89; Wien. Acad. Ber. 1849. Jan. 20.

(5) Ann. Ch. Phys. [3] X, 5, 175, 307, 385; XI, 82.



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polarising apparatus for the determination of the amount\* of crystallisable sugar contained in saccharine solutions has been rendered sufficiently convenient and satisfactory in its results since the optical saccharimeter has received its present form by the ingenuity and skill of Soleil.

Clerget(1), who has made a special study of the methods of saccharimetry in their application to the different varieties of sugar, publishes an accurate description of the apparatus just mentioned. The light with which the observation is made may be either day-light or lamp-light; it is admitted by a circular opening  $3^{\text{mm}}$  in diameter, at once impinging upon the polarising apparatus. In the horizontal saccharimeter described by Clerget this is an achromatised Iceland spar-prism (p), one image of which falls beyond the field of vision. Instead of this prism, especially if we only wish to make observations with solar light, a bundle of thin plates of glass may be employed. —The light thus polarised passes first through a circular plate of rock-crystal polished perpendicularly to the axis; this is cut through the middle of the field of vision, and one half turns to the right, the other to the left. Soleil selects their thickness at  $3^{\text{mm}}.75$  or at  $7^{\text{mm}}.5$ , because in the former case we find the ordinary image in the latter the extraordinary image of the analysing prism covering the entire field of vision with the well-known delicate hue (*couleur sensible*) lying between red and purple, from which the slightest rotation causes a transition into another shade. —The light moreover passes through a plate of rock-crystal(r) cut perpendicularly to the axis; then through two prismatic laminæ of rock-crystal(r) of equal power of rotation, though in a different direction from the previous plate, and with their refracting angles in reverse position. The planes bounding the right angle of these prisms are perpendicular to the optic axis of the rock-crystal, and to the path of the light in the instrument. The two prisms and their cases can be so slid upon one another by means of a rack-work, that they form a prism of variable thickness, the planes at the right angle remaining constantly parallel. One prism bears a scale, the other a vernier, so that the amount of displacement can be accurately determined to  $\frac{1}{1000}^{\text{mm}}$ .

The ray at last reaches an analysing, doubly-refracting prism(q), one image of which is excluded, the other being examined by a Galilian telescope. In the normal state of the instrument the double prism(r) and the quartz-plate(n) have the same thickness; consequently their effect is neutralised, as both possess an opposite power of rotation. The two halves of the double plate(m) in this case exhibit the same colour, and this is the most delicate hue. In order to test

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(1) Ann. Ch. Phys. [3] XXVI, 175; Intstit. 1849, 66 (in abstr.); Ann. Ch. Pharm. LXXII, 145.

the optical action of a liquid, it is introduced in tubes of from 20 to 22 centimeters in length between the laminæ(n) and(r) into Soleil's saccharimeter. The rotation effected by the liquid augments the effect of one half of the double-plate(m) and diminishes that of the other; both halves now appear unequally coloured.—In order to restore the equality of colour, it is enough to set the rack of the double prisms(r) to work in order to compensate for the action of the liquid column by increasing or reducing its thickness. Even assuming the liquid to be entirely colourless, this can only succeed if the law of dispersion of the differently coloured planes of polarisation be the same for the liquid and for quartz. This is the case with sugar; the instrument which we have just described is consequently applicable for the purpose of a saccharimeter. In order to maintain the *couleur sensible* of the double-plate for substances which are not easily rendered quite colourless, Soleil has inserted a Nicol's prism together with a lamina of rock-crystal cut perpendicularly to the optical axis between the polarising prism (p) and the source of light; the lamina assumes, as the prism (p) here serves as analyser, a hue varying with the position of the Nicol's prism, by the assistance of which the colour of the liquid is almost entirely or very nearly compensated.

If the liquid contains only a *single* optically-acting substance, its *specific power of rotation*, or rather its relation to that of quartz, may be determined once for all. It suffices therefore to know how great the rotation of the plane of polarisation is for a certain percentage, as the deflection is known to remain constantly proportional to varying percentages.

But even when cane-sugar occurs with several other substances possessing an optical action, it can still be determined quantitatively by optical means; it possesses the property which distinguishes it from all other substances having an optical action, of being convertible by a trifling operation into a body (grape-sugar) of opposite rotatory power. If the rotations which a liquid column of 20 centimeters in length (containing 1 per cent of various substances having an optical action) is capable of producing, are termed  $\alpha, \beta, \gamma \dots$ , and these values receive the positive or negative sign, according as the rotation is to the right or to the left; and if finally the amount of those substances contained in the liquid is  $A, B, C \dots$  per cent, the rotation will be altogether

$$D = \alpha A + \beta B + \gamma C \dots$$

If the substance  $A$  by transformation receives an opposite power of rotation  $-\alpha'$  for 1 per cent, whilst the other substances remain unchanged, we obtain

$$D' = -\alpha' A + \beta B + \gamma C \dots$$

and  $D - D' = (\alpha + \alpha') A$ , by which we lastly find  $A = \frac{D - D'}{\alpha + \alpha'}$ . The power of rotation of grape-sugar, or the value  $\alpha'$ , decreases as the

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temperature rises, as noticed by Mitscherlich formerly, and more recently by Clerget; the same value of  $D-D'$ , therefore, if observed at a low temperature, allows us to infer a higher percentage than at a more elevated temperature.

Clerget publishes a table in which, for a rising percentage, the effect of a gradual elevation of temperature between  $10^{\circ}$  and  $35^{\circ}$ , degree by degree, is given; hence the sum  $S$  of the readings in Soleil's saccharimeter corresponding to  $D$  and  $D'$ , affords, in every case, the true percentage and the temperature. We confine ourselves to giving a short abstract, and must leave it to those who desire to make farther use of the table to calculate the intervening numbers by a formula of interpolation such as

$$S = \frac{5 \cdot 1452 \cdot A}{1 + 0.0042 t}$$

where  $S$  is the sum of the two readings,  $A$  the weight-percentage, and  $t$  the temperature.

Sum of the readings before and after the Transformation of the Sugar, the latter readings being taken at						Amount.	
						Per Cent.	Grammes in 1 Litre of Liquid
$10^{\circ}$	$15^{\circ}$	$20^{\circ}$	$25^{\circ}$	$30^{\circ}$	$35^{\circ}$		
1.4	1.4	1.3	1.3	1.3	1.3	1	1.64
13.9	13.6	13.4	13.1	12.9	12.6	10	16.47
27.8	27.3	26.8	26.3	25.8	25.3	20	32.94.
41.7	40.9	40.2	39.4	38.7	37.9	30	49.41
55.6	54.6	53.6	52.6	51.6	50.6	40	65.88
69.5	68.2	67.0	65.7	64.5	63.2	50	82.35
83.4	81.9	80.4	78.9	77.4	75.9	60	98.82
97.3	95.5	93.8	92.0	90.3	88.5	70	115.29
111.2	109.2	107.2	105.2	103.2	101.2	80	131.76
125.1	122.8	120.6	118.3	116.2	113.9	90	148.23
139.0	136.5	134.0	131.5	129.0	126.5	100	164.71
152.9	150.1	147.4	144.6	141.9	139.1	110	181.18
166.8	163.8	160.8	157.8	154.8	151.8	120	197.65
180.7	177.4	174.2	170.9	167.7	164.4	130	214.21

Clerget gives copious directions for the preparation of the solution, for refining, decolourising, for transforming and treating the various kinds of sugar, of molasses, grape-juice and diabetic urine. We cannot, however, enter into the details of this part of his communication.

Poggiale(1) has indicated a method for determining the amount of milk-sugar contained in milk by optical means. He found that 201.9 grammes of milk-sugar, when dissolved in one litre of

(1) Compt. Rend. XXVIII, 505 and 584; Instit. 1849, 145 and 154; Ann. Ch. Pharm. LXXII, 161.

distilled water, afforded the same deflection as 164.71 grammes of cane-sugar.

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Biot had noticed that the albumin of the serum of blood caused the plane of polarisation to rotate to the left, and Bouchardat had found the specific power of rotation to be  $27^{\circ} 42'$ . A. Becquerel(1) has measured the proportion of albumin contained in the blood by the optical test, both in the normal condition and in a large number of diseases. He determines the specific power of rotation of albumin at  $27^{\circ} 36'$ . In health the serum contains from 7.5 to 8.5 per cent of albumin, which is indicated in a column of 20 centimeters in length by a deflection of from  $7^{\circ}$  to  $8^{\circ}$ .

With reference to the communication made in our last Annual Report(2), we have to state that Pasteur(3) has obtained two symmetrical hemihedral crystallisations from racemate of soda-ammonia, as well as from racemate of soda-potassa, the solutions of which rotate the plane of polarisation with equal power in an opposite direction, so that a mixture consisting of equal parts of both solutions is neutral in an optical point of view. The acid separated from one of the two hemihedral forms has been proved by Pasteur's careful examination, as well as by Biot's(4) accurate and extended series of confirmatory experiments, to be tartaric acid; the other acid is in every respect analogous to it; except that it is directly opposite to it in reference to circular polarisation, to its crystallographic, and its pyroelectric deportment. The crystals of both acids are doubly refracting with equal intensity, and in reference to double refraction belong to the same class of crystals.

Tartaric acid when dissolved in certain solvents, and then exposed to low temperatures, gradually loses its power of dextral rotation, and assumes the power of rotating in the opposite direction. Pasteur has not yet succeeded in fixing the acid in this condition, and of thus converting it into racemic acid of sinistral rotation. On this occasion, however, Pasteur has made the remarkable observation, that tartrate of lime, which rotates dextrally in an aqueous solution, assumes a sinistral rotation when dissolved in hydrochloric acid, whilst racemic acid, which rotates sinistrally, obtains a dextral rotation under the same circumstances.

Pasteur inclined to the view, that there might be a uniform connection between the occurrence of opposed and incongruent hemihe-

(1) Compt. Rend. XXIX, 625; Instit. 1849, 377; Ann. Ch. Pharm. LXXII, 162.

(2) Ann. Report for 1847 and 1848, Vol. I, 159.

(3) Ann. Ch. Phys. [3] XXVIII, 56; Compt. Rend. XXVIII, 477; Instit. 1849, 124; Ann. Ch. Pharm. LXXII, 164; see also the article on racemic acid in the Chemical Part of our Report.

(4) Ann. Ch. Phys. [3] XXVIII, 99; Compt. Rend. XXIX, 433; Instit. 1849, 337; Ann. Ch. Pharm. LXXII, 166.

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dral formis, and opposed optical rotatory power. This view has not, however, been confirmed by his examination of sulphate of zinc and sulphate of magnesia. Biot, moreover, points out that all substances at present known to possess a molecular power of rotation are of organic origin, and that no artificial chemical product possesses this power.

Biot has, in the treatise above (p. 83) quoted, given his reasons for assuming that the force which alters the direction of vibration of the æther during the passage of a ray of light through a fluid, is inherent in the molecules; and upon the strength of this Bouchardat(1) concludes that if a substance possessing an optical action enters into combinations, in which its molecule is neither decomposed nor transposed, the compound must equally rotate the plane of polarisation. This conclusion is confirmed in reference to formobenzoic acid prepared from amygdalin, for camphoric acid, in which the molecule of camphor is united with oxygen, but otherwise unaltered. Bouchardat found the specific power of rotation of camphoric acid equal to  $38^{\circ}875$  and dextral. It was considerably diminished by saturation with an alkali, and again restored by the addition of a strong acid.—Biot(2) considers the discovery of this optical property of camphoric acid as a great acquisition for optico-chemical investigations, as formobenzoic and racemic acids are too costly, and tartaric acid is less appropriate, on account of the deviation in its law of dispersion. Biot thinks that ethylo- and methylo-camphoric acid might also be applicable, and that their compounds with organic bases, their solutions in acetic acid and alcohol, compared with those of camphor, may present an interesting subject of investigation.

Biot has also shown, in the same treatise quoted at page 83, that the specific power of rotation of sugar is almost the same in the solid state and in solution, as it must be if the rotating power in reality proceeds from the molecules. Barley-sugar was the only substance that presented itself for the confirmation of this conclusion, as the crystals were unsuited to the observation of circular polarisation, on account of their much more powerful double-refraction, whilst the other amorphous substances were disqualified by their want of homogeneity and by their internal fissures, which it is difficult to avoid. Laurent having, however, lately succeeded in obtaining pure tartaric acid, as well as mixtures of tartaric acid with  $\frac{1}{10}$ ,  $\frac{2}{10}$ ,  $\frac{3}{10}$  . . . . of boracic acid in the solid amorphous state, perfectly transparent, Biot(3) availed himself of the very welcome opportunity thus

(1) *Instit.* 1849, 73; *Compt. Rend.* XXVIII, 319; *J. Pr. Chem.* XLVII, 445; *Ann. Ch. Pharm.* LXXII, 168.

(2) *Compt. Rend.* XXVIII, 321; *Instit.* 1849, 73; *Ann. Ch. Pharm.* LXXII, 169.

(3) *Compt. Rend.* XXIX, 681; *Instit.* 1849, 393; *Ann. Ch. Pharm.* LXXII, 169.

presented of obtaining farther confirmations of his theoretical conclusions.—If  $e$  represents the quantity of water in the weight-unit of a solution of tartaric acid, and  $(\alpha)$  its specific power of rotation, Biot formerly found  $\alpha = A + B \cdot e$ , where  $B$  is constant (the decimeter being the unit,  $=14^{\circ}315$ ) and  $A$  varying with the temperature at from  $21^{\circ}$  to  $22^{\circ}$  about equal to zero, positive for higher, negative for lower temperatures, which corresponds respectively to a dextral and sinistral rotation.—According to this, pure tartaric acid, for which  $e=0$ , should at the ordinary temperature have a rotation of the plane of polarisation equal to zero, or nearly so.—Fused tartaric acid, which was poured hot into rectangular vessels made of plate-glass, rotated strongly to the right at this high temperature. This effect diminished as it cooled, and a solid mass of  $70^{\text{mm}}$  in height, caused the plane of polarisation of the middle ray to deviate  $2^{\circ}$  to the left at  $15^{\circ}$ , and  $5^{\circ}$  at  $3^{\circ}5$ . The same values were as nearly as possible deduced from the formula. The experiments made with mixtures of tartaric and boracic acid, proved to Biot that the optical molecular force may be expressed by the formula  $(\alpha) = A + B \cdot e$ , in which  $e$  represents the amount of boracic acid contained in the weight-unit of the mixture. A more recent treatise of Biot(1) presents farther and more elaborate investigations, upon which we shall reserve our report till next year.

**Optical Instruments and Apparatus. Improvements in the Construction of Optical Instruments.**—Hitherto two kinds of eye-glasses have been employed in telescopes, the so-called *achromatic* eye-piece of Huyghens, and that of Ramsden; the former is also the one commonly employed as the eye-piece of the microscope.—In a tract devoted to this purpose, C. Kellner(2) dwells upon the defects of both eye-pieces, and announces an invention of his own, a new combination of lenses, by the name of the *orthoscopic eye-piece*. Kellner justly remarks that improvements in the construction of optical instruments can only proceed from an intimate combination of theory and technical perfection; this does not, however, induce us to undervalue such theoretic inquiries as Schleiermacher, for instance, has entered upon in his *Analytical Optics*. It is well known that the tendency of this work is to extend those calculations respecting optical instruments which have hitherto only been undertaken for points in the axis, to the entire field of vision, and also to take the higher terms of deviation into consideration. Unfortunately the second volume of the work, which was to contain the special applications to the usual instruments, and the tables for their easier calculation, has remained unpublished, on account of the sudden death of the learned author. Petzval has made calculations according to

(1) Ann. Ch. Phys. [3] XXVIII, 215 and 351.

(2) Das orthoscopische Ocular u. s. w., eine verbesserte Construction der Objectivgläser, nebst Anleitung zur richtigen Beurtheilung und Behandlung optischer Instrumente von C. Kellner, Optiker in Wetzlar; mit einem Anhang von M. Hensoldt, Anleitung zur Kenntniss und Prüfung der Libellen; Braunschweig 1849.

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the principle indicated, for a combination of lenses for a daguerreotype apparatus, which has been executed by Voigtländer; this shows what results the application of those researches would lead to.

The *achromatic eye-glass*, as is well-known, consists of a collector-lens, which accelerates the passage of the rays to the image, and at the same time enlarges the field of vision, whilst the second glass (also a simple crown-glass-lens) serves as a lens, and at the same time achromatises the principal rays of all the pencils of light. Kellner observes that in this eye-piece the image becomes somewhat convex towards the eye, whereas on the contrary it should be slightly concave if the entire field is to be distinct at the same moment. He concludes that it is impossible to see either the image or the cross-wires in the axis and at the edge with perfect sharpness, at the same position of the lens. He also states that the perspective of the images is interfered with by the eye-piece magnifying more at the edges than in the centre; that the spherical aberration is not avoided for the points in the axis, and the deviation of colour only for the principal rays that proceed from the centre of the object-glass; and also that the field of vision is surrounded by a strong blue margin. As these faults become more prominent with the enlargement of the field of vision, the mode usually adopted to obviate them is a disadvantageous limitation of the field.

These were not, however, the defects which induced Ramsden to substitute a new eye-piece in the instruments intended for astronomical mensuration—an eye-piece in which the image, and consequently the cross-wires, fall close to the first glass. His motive rather lay in the necessity of securing to the cross-wires a fixed position in the telescope, which it might be unnecessary to change on a transition to other powers, and in the wish that the cross-wires might appear to the eye better defined and larger.—Whilst, on the one hand, the indistinctness on account of the curvature of the image, the distortion of the perspective, as well as the spherical aberration in the axis, are less in this eye-piece than in the preceding one; yet, on the other, achromatism can only be attained very imperfectly externally to the axis, and in this respect this eye-piece is very inferior to the former.

The idea of applying achromatisation by means of flint-glass to eye-pieces easily suggested itself; but opticians have not hitherto carried it into practice, and even Fraunhofer was satisfied with executing the two eye-pieces under consideration with the utmost perfection. Precht(1), in his treatise on dioptrics, communicates the objections which opticians have to crown-flint-glass-eye-pieces, and these doubts are proper as long as the eye-piece is looked upon as consisting of a single or of two

(1) In Ch. Pharm

(2) Comp

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(aplanatic eye-pieces in microscopes). Kellner has succeeded in combining the advantages of the aplanatic eye-piece with a large field of vision. His eye-piece, as far as the position of the image and of the cross-wires is concerned, resembles that of Ramsden; the collector-glass is a simple crown-glass-lens; the second lens is double, and crown- and flint-glass are cemented together with Canada balsam; this lens affects the achromatism of the eye-piece, as the achromatising double lens of the dialytic telescope.—Kellner cites as advantages of this new construction of the eye-piece, that the entire field of vision appears perfectly distinct and in correct perspective at the same time; that the achromatism applies to the chief rays as well as to the other rays of the cone of light, that the blue edge is entirely got rid of, that the position of the eye is farther removed from the last glass surface, and consequently permits of more convenient observation for high powers, and lastly that the field of vision is twice as large in higher powers as that of the equivalent single lens, or equal to that of the older achromatic eye-piece; and also that in lower powers this limit may be considerably transgressed, whilst on the other hand, if we are ready to sacrifice some of its advantages, we may with its assistance employ the highest astronomical powers(1).

Although the reporter has been able by personal inspection to convince himself, though only by terrestrial objects, of the reality of the advantage of the new construction of the eye-piece, he does not venture to place his judgment in the scale with that of Gauss and H. Muhl, who have tested and confirmed the excellence of the eye-piece; the former in a six-feet refractor by Merz, the latter in a microscope of Amici.—Gauss says, in a letter to the artist, "When applied to the telescope of Merz, the eye-piece magnifies 96 times, and is therefore fully equal to one of the eye-pieces of Merz. I have perceived no difference of any importance relative to the distinctness and achromatism of the image. But your eye-piece has a field of vision of  $27^{\circ} 36''$  diameter, whilst that of Merz has only  $18^{\circ} 25''$  in diameter, consequently the surface of the field is almost twice as large with your eye-piece as it is for an equal power with Merz's glass. The distinctness of vision to the very edge of the field is, if not as good, still very nearly as good, in your eye-piece as in the other."

Kellner has also introduced a new construction of object-glasses, not by applying either Herschel's nor Littrow's methods, but by making such an arrangement of the radii that the two curvatures of the internal surfaces are always rendered equal for all varieties of glass; these surfaces are then joined together by Canada balsam, which obviates the loss of light by reflection from these surfaces.—Lastly,

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(1) Whereas, according to Precht (practische Dioptrik, 191—193), the older achromatic eye-pieces only go down to a focus of 4 par. lines, Kellner has constructed them of from  $28''' \cdot 8$  (for comet seekers) to  $2''' \cdot 66$  focal distances of the equivalent simple lens.



Lord  
Rosse's  
reflecting  
telescope.

Kellner has lately transferred the principle of his eye-piece to terrestrial telescopes, so that he makes the second and fourth of the four eye-pieces of crown- and flint-glass. The field of vision is thereby considerably enlarged, a quality which is particularly advantageous in these telescopes.

**Lord Rosse's Reflecting Telescope.**—Airy(1) has communicated a detailed report to the Royal Astronomical Society on the method adopted by Lord Rosse and Lassell in casting, framing, cutting, polishing, and uniting to the tube, their concave mirrors of respectively 6 and 2 feet width, and 50 and 20 feet focal distance, as well as on the construction of the machinery for the movement of the telescopes.

Robinson and Lord Rosse himself have made farther reports(2) to the *British Association* on the instrument and the observations made with it, especially the resolutions of the nebulae.—The former states that a deviation from the parabolic form of one hundred thousandth part of an inch at the circumference, would have made the mirror imperfect in an optical point of view; a deviation of one-millionth of an inch at any part from the proper focal distance would easily have been discovered. The light of Sirius seen by this instrument was as little bearable to the eye as the electric light between charcoal-points. Rosse particularises the nebulae which have been resolved during the years 1845, 1846, 1848 and 1849.

**Other Optical Apparatus.**—Schellbach(3) describes his method of delineating caustic surfaces as a means of facilitating the study of catoptries and dioptries.—Emsmann(4) gives information regarding the construction of the anamorphoses of the conical mirror.

**Wave-Machine.**—Plücker(5) has made a communication on a wave-machine constructed by Fessel. It is a farther elaboration of Wheatstone's idea, to represent the various states of polarisation by little rods of equal length provided with buttons at the upper end; which are struck against wave-trains of various forms. Fessel's machine exhibits the true movement of the particles of aether, both in the light-wave that falls upon a doubly-refracting crystal as in the two light-waves in the interior of a crystal, and more particularly the rays of circular polarisation, which are propagated along the axis of the rock-crystal.

**Electric Light for Optical Purposes.**—Foucault(6) has discovered the means of rendering the electric light between charcoal-points constant, and thus available for optical purposes. The charcoal-holders are made to approach to one another by springs, but cannot be brought together without setting a wheel-work in motion which at other times is kept

(1) Phil. Mag. [3] XXXIV, 532.

(2) Instit. 1849, 366.

(3) Pogg. Ann. LXXVI, 606.

(4) Pogg. Ann. LXXVII, 571.

(5) Pogg. Ann. LXXVIII, 421.

(6) Compt. Rend. XXVIII, 68, 698, Instit. 1849, 17.

from moving by a detent. If the current and consequently the light becomes too weak, the detent is released, as it is only retained in its position by an electro-magnet; the pieces of charcoal approach one another, the current and, at the same time, the electro-magnet is strengthened, the detent catches again, and prevents a greater approximation of the pieces of charcoal.—The commission of the Academy of Paris(1) has convinced itself of the originality of the invention of Foucault, although an Englishman, E. Staite, had preceded him in its publication(2).—The priority of invention has been claimed by Gaigneau(3) for W. Petrie of London. (See the Report on Electricity).

**Employment of Polarised Light in Microscopic Investigations.**—Ehrenberg(4) has drawn attention to the great utility of employing polarised light in botanical investigations. He has made the structure of starch-corpuscles in a great number of plants his particular study, and also publishes a very long list of similar observations in inorganic and organic bodies.

**Optics of the Atmosphere. Atmospheric Reflection of Light.**—Clausius(5) has instituted a learned investigation into the nature of those constituents of the atmosphere by which the reflection of the light is produced in it. We are only able to give the ideas which have led the author to his main inferences and results: we must refer the reader to the original for the details of execution, and especially for the mathematical deductions. In the first instance, Claudius points out that the reflection cannot take place at the boundary-surfaces of atmospheric layers of various densities surrounding the earth, as these boundary-surfaces could only reflect the solar light in certain directions, which would never strike the earth, and that consequently the sky would appear perfectly dark. Although we are inclined to think that the light would by repeated reflections from such surfaces actually reach the earth, it is evident that an observer could not receive light from all points of the horizon by this reflection; besides the constant increase in the density of the atmosphere from above downwards prevents the existence of such distinct layers with reflecting boundary-surfaces.—In the second place, Clausius devotes some consideration to the assumption that the reflection is effected by foreign opaque particles, which are uniformly diffused through the atmosphere like dust. He rejects this view as improbable, nay, as absolutely inexplicable. Clausius pays no attention to the ultimate particles of the air, the atoms of oxygen and nitrogen, which, like those of all other substances,

(1) Compt. Rend. XXVIII, 120; Instit. 1849, 44.

(2) Illustr. Angl. 18 Nov. 1848

(3) Compt. Rend. XXVIII, 157; Instit. 1849, 34.

(4) Berl. Acad. Ber. 1849, 55; Instit. 1849, 255.

(5) Pogg. Ann. LXXVI, 161.

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must be looked upon as opaque, probably because on account of their extreme tenuity he expects no reflecting action from them. —If we are therefore constrained to conclude that the reflection can be effected only at the boundary-planes of transparent media, these must be supposed to be solid aqueous corpuscles, or aqueous vesicles, or small atmospheric particles, such as complex molecules, which are separated by empty spaces, or, lastly, adjoining masses of oxygen and nitrogen.—In every case reflection and refraction coincide, and the different assumptions must be judged according as the phenomena caused by the latter correspond with, or are opposed to fact. —Now as the rectilinear propagation of light can only co-exist with a refraction by bodies possessing parallel boundary-planes, Clausius at once determines that atmospheric reflection is produced by vesicles of aqueous vapour, which must be suspended in the air in sufficient quantity even in fine weather. Here we have four reflecting planes, but the refraction cannot materially interfere with the path of the light, as it takes place both at the entrance and exit of the ray at two planes that are almost parallel.—In order to prove the inadmissibility of reflection and refraction by solid masses of water or air, Clausius proceeds to show, that if we suppose such masses of every possible form distributed in the atmosphere, the total effect will be the same as if all these masses had a globular form, a case which is then subjected by Clausius to a mathematical analysis, in two distinct problems; in one he assumes the refracting power to be somewhat high, about equal to that of water, in the other equal to 1, corresponding to the transition from a vacuum to air, or from oxygen to nitrogen.

For the first case Fresnel's formulæ of reflection lead to a loss of light by reflection at the anterior and posterior surface of a globe of water = 0.12, the intensity of the incident light being = 1. Now as the light of the sun in the zenith suffers a diminution amounting, according to Bouguer, to 0.19, according to Lambert, to 0.41, or in the mean to 0.30, each descending ray must meet with two or three globes of water; or when the sun is in the horizon, and the passage of the light through the atmosphere is 35 times longer, it must strike from 70 to 100 globules. If we examine the refraction and dispersion which the light would thus experience, it results(1) that the sun would in the zenith appear, not as a well-defined disc, but that instead we should observe a large luminous space descending to below 60°.—The second case, in which the refracting ratio of the reflecting masses is assumed at nearly 1 (for the transition from empty space to air  $n = 1.000294$ , into oxygen  $n = 1.000272$ , into nitrogen  $n = 1.000300$ , and from oxygen to nitrogen  $n = 1.000028$ ), is extensively treated by Clausius on mathematical principles; this forms the main portion of his treatise, but it is the more difficult to give an abstract of it, as the

(1) Pogg. Ann. LXXVI, 169 and 170. .

author has adopted a very compendious style. He gives the terms for the magnitude of the reflection and dispersion of light; these, when applied to the light of a fixed star, and after the determination of the constants with the assistance of the numbers of Bouguer and Lambert above quoted, lead to the result, that for the following values of  $n$ , the fixed star should not appear as a point, but as a circle of the radii marked below:

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$\frac{n}{r}$	$\frac{1.0003}{5^{\circ} 29'}$	$\frac{1.00003}{2^{\circ}}$	$\frac{1.00001}{1^{\circ} 13'}$	$\frac{1.000001}{25.7}$	$\frac{1.0000001}{8.8}$	$\frac{1.00000001}{3.31}$
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These considerations prove the impossibility of assuming, that reflection in the atmosphere is caused by opaque masses with unparallel boundary-planes; the only hypothesis, therefore, that remains is the one that refers the phenomenon to reflection by aqueous vesicles.

For the farther confirmation of his opinion, Clausius(1) demonstrates that it permits a satisfactory deduction of the blue colour of the sky, as well as the orange colour of the setting sun, and the redness of sunrise and sunset. For this purpose he applies the theory of thin plates to the aqueous pellicle forming the vesicles.—Let  $\delta$  be the thickness of the pellicle,  $i$  the angle of incidence of an homogeneous pencil of light of the wave-length  $\lambda$  and of the intensity  $a^2$ , let the strength of reflection be measured by the factor  $r$ , then the intensities ( $b^2$  and  $c^2$ ) of the reflected and transmitted light will be, if multiple reflection be taken into account,

$$b^2 = a^2 \cdot \frac{4r^2 \cdot \sin^2 \left( 2\pi \frac{\delta \cos i'}{\lambda'} \right)}{(1 - r^2)^2 + 4r^2 \sin^2 \left( 2\pi \frac{\delta \cos i'}{\lambda'} \right)} ; c^2 = a^2 \cdot \frac{(1 - r^2)^2}{(1 - r^2)^2 + 4r^2 \sin^2 \left( 2\pi \frac{\delta \cos i'}{\lambda'} \right)}$$

in which formulæ  $i'$  represents the angle of refraction, and  $\lambda'$  the wave-length in the interior of the lamina.—As these terms are dependent upon  $\lambda'$ , the lamina operates unequally upon the different colours, white light is coloured by it both in the reflected as in the transmitted ray.

In reflected light the intensities of the single colours may vary between the limits 0 and  $a^2$ .  $\frac{4r^2}{(1+r^2)^2}$ . If the thickness  $\delta$  is exactly  $= \frac{1}{4} \lambda'$  for the extreme purple, and if we examine the light that has a perpendicular incidence, purple will have a maximum of reflection, the other rays will be reflected the less, the greater their wave-lengths, and this relation continues for oblique incidences, only that

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in that case also the violet no longer continues at a maximum of reflection. In every case a blue colour of the reflected light results, and this is the case for all lesser thicknesses than the one above assumed, up to that point at which the lamina becomes so thin as no longer to reflect light. If, on the other hand, the lamina increases in thickness, the reflected light gradually passes through the well-known Newtonian colours, blue, white, yellowish-white, orange, red, purple-blue, &c. Whereas, therefore, in bright weather, when the vesicles are thinnest, the air must appear blue, we must not suppose that in damp weather the atmosphere, and eventually the clouds, successively should show the above colours. There will then, indeed, be vesicles with thicker walls, but also others of every minor thickness; more of the above colours will become mixed, and the colour of the horizon will accordingly pass more and more into white.

In transmitted light the difference between the minimum and maximum of the different rays is as great as in the reflected light, but there is a greater admixture of unaltered white light in transmitted light, so that the sun appears almost white in the zenith, and only assumes a distinct orange tint in the vicinity of the horizon, which is simply reflected by the clouds in sunset and sunrise. The author might, in support of his view, have added that in a thick fog the colour of the sun by no means passes into a deeper red or orange, but approaches to white, as demanded by the above theory. The labours of Clausius, which have here been discussed, are published by the author in Grunert's "Beiträgen zur meteorologischen Optik, erster Theil, 4. Heft," in connection with the other optical phenomena of the atmosphere.

**Optical Polar Clock.**—Wheatstone(1) points out, that intricate as may be the law of the intensity of the light polarised by reflection in the atmosphere, the plane of polarisation may yet be found by a very simple position, probably first determined by Babinet; this plane coinciding with the one which passes through the point of the sky under observation, through the sun and the eye of the observer.—The plane of polarisation passing through the pole, consequently indicates the true solar time, at every period of the day. Based upon this fact, Wheatstone has constructed his so-called polar clock. He attaches at the upper end of a perpendicular pillar a glass plate, held by a brass ring: this is directed perpendicularly to the axis of the earth; at the lower part of the circle it is divided into 12 equal parts, and each of these again into 10 subdivisions, corresponding to the hours, &c. A conical tube fits into the brass ring, the axis of which is parallel to the axis of the earth; and at its wide opening a star of thin selenite on a glass plate, at its narrow one a Nicol's prism is

attached. The principal sections of the lamellæ, forming the rays of the star, are all parallel, inclined at an angle of  $45^\circ$  to the plane of polarisation of the Nichol's prism, and directed so that the lamellæ in the same position simultaneously appear colourless. The central portion of the star is then directed exactly so as to exhibit the maximum of red colour. Lastly, a black line, to serve as index, is marked on the glass plate which bears the star of selenite in the direction of a principal section of the crystalline laminae; this index gives the position of the plane of polarisation of the light reflected from the sky, and consequently determines the hour.—It is apparent that this clock is applicable in localities where the sun-dial is useless; it indicates the hour some time before sunrise and after sunset, and even answers its purpose when the sky is not too much clouded.—Wheatstone describes other instruments of a very beautiful construction.

Soleil(1) has also constructed an optical polar clock upon Wheatstone's fundamental principle. A polariscope, made to revolve round a horizontal axis, is attached to a perpendicular support in such a manner that, by a vertically-divided circle, its optical axis, at any time, can be adjusted to the polar altitude of the place. The polariscope contains the well-known double plate of quartzes of opposite rotation, and by the equality of colour the direction of the plane of polarisation is recognised. A circle divided into hours and minutes is applied perpendicularly to the optical axis of the polariscope.—In order to observe with greater convenience, a reflecting prism and a telescope are placed before the polariscope.

Arago(2) observes, that he talked about a similar instrument with Humboldt as early as the year 1816, though he by no means wishes to deprive Wheatstone of the honour of his invention. He adds, however, that the practical use of the instrument, independent of the uncertainty in the observation of the colours, is subject to many considerable difficulties which especially depend upon the disturbance of the normal state of polarisation caused by the multiple reflection in the atmosphere.

**Colour of the Sun and its Spots.**—Busolt(3) allowed the image of the sun to fall through the six-foot heliometer of the Königsberg Observatory first upon white paper, and then upon a disc of the finest gypsum cast on a mirror. He believes that he has discovered the peculiar colour of the solar spots to be purple, and that they are surrounded by a splendid yellow, and a larger pale yellow halo. The sun itself is said to present a colourless surface which is sprinkled over with purple spots.

**Mirage.**—Hopkins(4) has found in his observations on the coast

(1) Compt. Rend. XXVIII, 511; Instit. 1849, 162.

(2) Compt. Rend. XXVIII, 513.

(3) Pogg. Ann. LXXVI, 160.

(4) Instit. 1849, 351.

Mirage.

of Lancashire, that in most cases in which atmospheric reflections are observed, strata of air that are tolerably near, present a considerable difference in their hygrometric state.

**Rainbow by Gas-light.**—Faye(1) observed during a dense fog that a white arch of light was produced by a gas-light in the same manner as a rainbow is produced by the sun. The diameter included about  $80^\circ$ , whilst the gas-light stood at a distance of from 4 to 5 meters behind the observer.

We also direct attention to the following observations: an observation on atmospheric reflection in a high wind by Thury, communicated by Wartmann(2); observations of narrow shadows and bands of light proceeding from the setting sun, by Wartmann(3); of a rainbow after sunset, by Chevallier(4) of a double halo round the sun, by Plantamour(5); of a halo and satellite moons, by Bravais(6); and of the aurora borealis, by various observers(7).

**Physiological Optics. Erect Vision.**—From a report(8) on an essay by Zenneck, "Zusätze zu meiner Erklärung des Aufrechtsehens," it appears that this author considers all the explanations hitherto given as unsatisfactory. He states that the inverted retinal-image is physical, and not physiological; and that the iris in its mobility, its probably sensitive nature, and its position relative to the retina, unites the conditions which permit the affections of the retina to afford an erect image.(1) He challenges the ophthalmologists to promulgate their experience and their views on this subject.—Unless Zenneck's views have been entirely misrepresented by the report from which we derive them, it will be long before his wishes will be gratified by ophthalmologists.

**Smallest Image on the Retina. Adaptability.**—Marié-Davy(9) drew lines on a white ground with intervals equal in size to the thickness of the lines; he then removed them from the eye until they could no longer be distinguished, and only offered a grey surface. The angle of vision at which they disappeared remained nearly the same in different systems of unequal fineness. The images in that case occupied on the retina  $0^{\text{mm}}\cdot 0011$ ; Marié-Davy concludes that the size of a simple papilla of the retina is  $= 0^{\text{mm}}\cdot 0022$ , viz. as large as the breadth of the image of a line together with its interval at the moment of disappearance. Volkmann(10), on the other hand, found the

(1) Compt. Rend, XXVIII, 244; Instit. 1849, 57. (2) Arch. Ph. Nat. X, 291.

(3) Arch. Ph. Nat. X, 293, 294; Phil. Mag. [3] XXXIV, 469; Arch. Ph. Nat. XII, 40; Instit. 1849, 352.

(4) Instit. 1849, 312.

(5) Ibid. 138.

(6) Compt. Rend. XXVIII, 605; Instit. 1849, 153.

(7) Phil. Mag. [3] XXXIV, 226; XXXV, 71; Instit. 1849, 303, 304; Arch. Ph. Nat. XII, 222, 228, 230.

(8) Jahrbücher d. ges. Medicin LXIV, 158.

(9) Instit. 1849, 59.

(10) Pogg. Ann. XLV, 193, 207

smallest perceptible image on the retina  $= 0^{\text{mm}} \cdot 0005$ , and the image of the smallest interval in which two spider-webs were separately visible  $= 0^{\text{mm}} \cdot 005$ . Treviranus states the diameter of the simple papilla to be  $0^{\text{mm}} \cdot 0038$  in the hare, Weber,  $0 \cdot 003$  in man.—Marié-Davy is moreover of opinion, that when the image on the retina is less than  $0^{\text{mm}} \cdot 0022$ , it does not cease to be visible, but that it becomes pale, and that it no longer possesses an angle of vision which diminishes in the ratio of the distance; and also that every nervous fibril conveys to the brain the impression of a single papilla, and that consequently the image is in reality of a mosaic character. Marié-Davy's remarks on the adaptability of the eye are well founded, so far as he shows that the variation in the width of the pupil, and a displacement or change of form in the lens, do not suffice to explain that property. But before adopting his assertion, that the adaptation is brought about by the muscles of the eye, by elongating the axis of the eye, and giving the cornea a stronger curvature, we require some experimental proof, or at least the removal of some of the well-known objections to this view.—According to Marié-Davy, the lens exerts a very trifling influence in seeing, and he makes short and far sight to depend much more upon the curvature of the cornea than of that of the lens.

Smallest  
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the retina.  
Adaptability.

Haldat(1) informs us, that although he exerted himself to the utmost, and made his observations conscientiously, he was unable to see a needle distinctly that was placed at a shorter distance from the eye than the ordinary range of vision; from this he concludes that the eye does not possess an optional adaptability. Haldat also confirmed the fact, that when a diaphragm with a very narrow orifice is used, two objects that are at different distances may appear distinct at the same time.

**Single Vision with two Eyes.**—J. Locke(2) communicates the results of experiments instituted during the years 1816, 1843, 1845 and 1846 on single vision with two eyes, and which, as he himself remarks, are merely confirmatory of the stereoscopic experiments of Wheatstone, and of a few experiments by Brewster(3). Locke is in favour of the theory of corresponding points on the retina, without investigating the cause.

**Stereoscope.**—Brewster(4) has given the stereoscope of Wheatstone a new shape, so that it may be held up to the eye like a double opera-glass. One looks through two well-adapted lenses.—Another instrument of the same physicist likewise contains two lenses, and serves to give two views of the same body in the daguerreotype-

(1) Arch. Ph. Nat. X, 300.

(2) Sill. Am. J. [2] VII, 68; Phil. Mag. [3] XXXIV, 195; Froriep's Notizen IX, 227.

(3) Annual Report for 1847 and 1848, Vol. I, 167.

(4) Instit. 1849, 344.



Stereoscope.

apparatus, as they are necessary to produce the impression of corporeal dimensions in the stereoscope. In order to obtain two lenses of exactly the same focus for this apparatus, Brewster proposes cutting a lens into halves. He believes this method to be useful when it is required to obtain two telescopes or microscopes of exactly the same focal lengths. It is well-known that two halves of lenses are employed in the heliometer.

**Vision with two Eyes.**—Foucault and J. Regnault(1) have employed the stereoscope of Wheatstone to determine whether complementary retina-images produce the impression of white on corresponding points of both eyes.—Two complementary rays, obtained by chromatic polarisation, were thrown in a horizontal direction on the mirrors of a stereoscope, and reflected from them on the screens attached at the sides, so that two small discs of paper placed at the same height were coloured by them.—At first the observer saw alternately one or the other complementary colour; after a time, however, the two impressions united to form white the more easily, the lower the intensity of both rays; and when the eyes had once become accustomed to this, a whole series of complementary colours could be introduced successively, and the observer saw nothing but white during the entire experiment. Of all the colours, blue and yellow were most adapted to combine to form white even from the commencement. Both complementary rays being of unequal intensity, they yielded white, but it was combined with a weak tint of the prevailing ray.—It here deserves to be mentioned that as early as 1841, Dove(2) instituted and made known a very similar experiment. He placed a plate of mica of uniform thickness before a stereoscope, and allowed light to pass through the sides, into which circular openings had been cut, upon the uncovered mirrors of the stereoscope; he then examined the image of the opening with two Nicol's prisms, whose planes of polarisation were perpendicular to one another, and found the opening colourless. The French physicists ought not to have left this experiment unnoticed. As Dove (*loc. cit.*) observes, that the experiment did not succeed when made with an ordinary polarisation-mirror, the reporter is able to add, that he has frequently observed the complementary colours of gypsum-laminæ combining to form white in Nörrenberg's apparatus.—The experiment easily succeeds, if the entire field is covered with the exception of a circular opening, and the observer attains the power of directing the axes of his eyes for some time immoveably upon one point. The reporter found that there are not certain colours like blue and yellow which have a peculiar facility in combining, but that the combination is effected with a facility proportionate to the order of the component colours.

(1) *Compt. Rend.* XXVIII, 78; *Instit.* 1849, 3; *Phil. Mag.* [3] XXXIV, 269.

(2) *Berl. Acad. Ber.* 1841, 251; *Pogg. Ann.* LXXI, 111.

**Observations of Periodical Motion.**—Plateau has in former years proposed a method for the purpose of removing the optical illusion caused by rapid periodical motion. It consists in placing between the eye and the moving object an opaque disc, provided with small holes at equal distances from one another, and allowing it to rotate about its centre in its plane with a suitable velocity.—Plateau(1) now remarks that this method is more adapted to the observation of the continuous liquid jet, than the proceeding adopted by Savart; he claims the priority of the suggestion, in opposition to a treatise of Doppler, and a note of Poggen-dorff(2).

Observa-  
tions of  
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motion.

**Duration of Impressions made on the Retina.**—Plateau(3) describes an optical experiment, and states the impression it makes as very surprising. He takes two discs of exactly the same size, made of thick white paper, and divides one into 8 equal sectors, of which two and two corresponding and opposite ones are coloured red, white, blue, and black; the second disc is coloured entirely black, two sectors lying opposite to one another, and rather shorter and narrower than those of the first disc, are cut out. Both discs are then attached to rollers, which are as much equal to one another as possible; they are placed vertically behind one another, so that the axes of rotation coincide, and the rollers are set in motion by cords which pass over two larger wheels, which are likewise as nearly as possible equal to one another. The posterior coloured disc, which is rendered transparent by varnish, is well lighted from behind by a lamp. If the arrangements made to attain a perfect equality in the rotation of both discs are as complete as possible, there will always remain a trifling irregularity. When, therefore, at first the open sections of the front disc are opposite to the black sectors, the whole field appears black; but by gradual transitions it passes into red, then into white, and lastly into blue, as continuously other sectors move into the field of the open sections.

**Anorthoscope.**—The anorthoscope of Plateau, the general theory of which this inquirer has lately developed(4), possesses a similar arrangement. The anorthoscope, which serves to produce a peculiar kind of anamorphoses, consists of a transparent disc, on which the distorted figure is drawn, and of an opaque black disc, which is provided with a small number of narrow slits, in the direction of the radii. Both discs rotate before one another, in the same or in opposite directions, so that their horizontal axes of rotation coincide when prolonged. The transparent disc is well illuminated from behind.—It is evident that the image obtained is composed of the impressions made by the points lying behind the fissure, in the different positions of the fissure,

(1) Pogg. Ann. LXXVIII, 284.

(2) Ibid. LXXII, 530.

(3) Instit. 1849, 205; Pogg. Ann. LXXVIII, 563.

(4) Instit. 1849, 277; Bull. de l'Acad. de Brux. XVI; Pogg. Ann. LXXIX, 269.

Anorthoscope.

and it is easily intelligible that the distorted figure must in every case be derived from the regular one through an extension or contraction in the direction of the angular velocity.—The character of the drawing varies according as the rotations of both discs are made in the same or opposite directions, and according to the ratio of the velocities.

I. If the rotation is in *an opposite direction*, the figure must always be drawn extended on the transparent disc. Let  $V_d$  represent the velocity of this disc, and  $V_n$  that of the black disc in front, and  $M$  the angular ratio of the natural and the distorted figure, then  $M = \frac{V_d}{V_n} + 1$ . In the anorthoscope of Plateau the velocity of the posterior disc was 4 times greater than that of the anterior one, and the figure seen was derived from the natural one by a five-fold enlargement of the angular distances. The mode of drawing requires no specification. The ratio  $\frac{V_d}{V_n}$  must always be expressed by a whole number, if the impressions in each successive revolution are to fall upon the same spot, as in the previous one, or, in other words, if the figures are to remain in the same position. The figure does not then however appear single, but as often repeated as there are units in  $M$ ; the drawing must consequently at most occupy  $\frac{1}{M}$  of the entire circle, if the  $M$  figures are to appear separated from one another. We may introduce  $\frac{V_d}{V_n}$  equidistant slits in the anterior black disc. The impressions which each slit makes by itself then cover each other, and the image appears lighter.

II. If the rotations of both discs occur *in the same direction*, the relation of the angular extension of the distorted and regular figure is  $M = 1 - \frac{V_d}{V_n}$ . Plateau distinguishes two chief cases.

1. If  $V_d < V_n$ , the distorted figure must be the more strongly compressed the more the ratio of the velocities approaches to unity. If the impressions of the successive revolutions are to cover one another, the denominator of the fraction  $\frac{V_d}{V_n}$ , when reduced to its simplest form, must exactly exceed the numerator by one unit.—The natural figure occupies the entire circumference, if the distorted one is drawn  $\frac{1}{M}$ . In order to increase the vividness of the impression, the latter may be repeated  $M$  times on the opaque disc, and  $V_d$  equidistant slits may be introduced in the opaque disc.

If rollers and cords are used, the ratio of the velocities can never be accurately regulated, and the consequence is that the image moves slowly.

2. If  $V_d > V_n$ , the value of  $M$  is rendered negative. The regular figure seen in this case bears the same relation to the distorted one, in

position, as a mirrored reflection to the object. The three cases  $V_d > 2 V_n$ ,  $V_d = 2 V_n$ , and  $V_d < 2 V_n$  are to be well distinguished. Each system belonging to the case of  $V_d > 2 V_n$  corresponds to a system of No. I, with the sole difference that the image appears inverted. The same disc may be employed, if fixed inversely to its axis; in this case  $\frac{V_d}{V_n} = 6$  corresponds to  $\frac{V_d}{V_n} = \frac{3}{4}$  in No. I, as  $M$  retains the same value in both cases.  $M = -1$  corresponds to the case of  $V_d = V_n$ ; we here merely obtain a reversion of the figure without farther change of form, and we employ two slits that lie in the same diameter. Lastly, to the case  $V_d < V_n$  a case in No. I invariably corresponds. Here we have in the fraction  $\frac{V_d}{V_n}$  the numerator greater than the denominator by a unit; for instance, in this case, the ratio  $\frac{5}{4}$  yields the same result as the ratio  $\frac{3}{4}$  in opposite rotation.

Plateau has employed the principle of his apparatus(1) for improving the phenakistiscope, so that the optical illusion is secured in a much higher degree, and that the phenomenon may be seen with both eyes, and even simultaneously by several observers.

Supposing the discs to be rotated in opposite directions, so that  $V_d = 1$ ,  $V_n = 4$ , then the relation of the angular dimensions will be  $\frac{1}{4} + 1 = \frac{5}{4}$ . If therefore the disc is divided into 20 equal sectors, and 16 of these are filled with the same figure in 16 consecutive phases of motion, as is commonly done in the phenakistiscope: if then the transparent disc of the anorthoscope is divided into 16 equal sectors, and the 16 figures mentioned are transferred to it, with an angular extension in the ratio of 4:5, we shall, if 4 equidistant slits are made in the opaque screen, on rotation see 16 figures, which are all engaged in the movement represented by the drawing. The representation is produced with the greatest effect if an opaque screen is applied close to the transparent disc, which is only cut out sufficiently to admit the light, and to leave one of the 16 figures (as, for instance, the one in the vertical position) visible. If the apparatus is placed in a dark room, and all the light is intercepted by a transparent screen, so that only the one illuminated field of the transparent discs remains visible, the illusion is complete.

The employment of the immoveable opaque screen certainly presupposes the relation of the velocities of rotation to be not only approximatively, but absolutely attained, as otherwise the figure would not retain the same position. Plateau has for this purpose attached to each of the moveable discs a wheel, with teeth cut perpendicularly to its plane, which are set in motion by the same steel axle, with a rack placed between the two toothed wheels. The toothed wheel

Anorthoscope.

of the transparent disc has a diameter of 6 centimeters, and 4 times less teeth than the other. Plateau publishes the dimensions of a very effective apparatus which he has employed, and points out that the illusion may be considerably increased by combining the anorthoscope and phenakistiscope with Wheatstone's stereoscope, as we thus obtain the view of moveable bodily figures; he proposes a method by which the drawings are best made for this purpose.

**Irradiation.**—Powell(1) has communicated a treatise on irradiation, its cause, its occurrence in vision with the naked eye and by the telescope, its measure and operation in astronomical observations. He is of opinion that the cause of irradiation is not to be sought in an affection of the retina, which extends beyond the geometrical limits of the image; but that it is rather a phenomenon of an optical character, as the same enlargement of the luminous field is seen in an artificial eye(2) and in the camera obscura. If we rightly understand Powell's meaning, he looks upon diffraction as the cause of the phenomenon. He, however, remarks, that the difficulty of explaining the phenomena of irradiation is increased by their sometimes occurring, at others being absent, in apparently the same circumstances.

**Vision in a Fog.**—Luvini(3) points out that in fogs, especially if bright, we see better with the telescope if a red glass is placed before it.

**Subjective Optical Phenomena.**—Haidinger(4) states, that when both eyes are directed against a grey, cloudy sky, then both completely covered with the hands, and the hand is at last suddenly withdrawn from one eye, a rather lighter spot appears close to the direction of vision, which is crossed by two still lighter lines forming, at angles of  $45^\circ$  with the horizon, a cross of St. Andrew. The appearance rapidly becomes less vivid as it disappears with the impression of the remainder of the field of vision. According to Wedl, the probable site at which the cross is formed, is the cornea. This consists of fibres placed in such a manner above one another as to form a grating, the square orifices of which allow the passage of most light in the diagonals. It is to be remarked, that if an artificial grating of the same character is directed towards an illuminated surface, we certainly do not obtain the phenomenon of a cross.

**Haidinger's Pencils of Light.**—Haidinger(5) has critically examined the explanations given on the one hand by Silbermann(6), and on the other by Jamin(7), of the phenomenon of the pencils of polarisation. He quotes the fact, that if an opening of not more

(1) Instit. 1849, 288; 1850, 47; Phil. Mag. [3] XXXIV, 459.

(2) But also seen finally with the retina.

(3) Instit. 1849, 8.

(4) Wien. Acad. Ber. 5. Hft. 4.

(6) Annual Report for 1847 and 1848, Vol. I, 159.

(5) Ibid. 12.

(7) Ibid. Vol. I, 160.

than  $\frac{1}{3}$  mm in diameter is applied close to the eye, and we examine through it a linearly polarised luminous plane, the pencils are still very distinctly seen in the direction of the axis of vision. "We may thence conclude," observes Haidinger, "that it is a single point of the smallest possible dimensions, from which a cone of rays issues, within the base of which, on the retina, the pencil is to be found." The meaning of these words is *bond fide* unintelligible to us. If, on the other hand, Haidinger remarks, that the apparent radius of the light-bundles, measured from the axis of vision, is only  $3^\circ$ , a fact of which any one may easily convince himself who is at all able to perceive the pencils, we are obliged to concede that the light pertaining to the pencils only penetrates the central portion of the lens in which the radial fibrous structure has not been noticed.

Haidinger's pencils of light.

The explanation of Jamin does not appear satisfactory either, if we consider the trifling difference between the incidences of the rays from zero for a field of vision of  $6^\circ$ . — The objection of Haidinger, that Jamin deduces from his explanation dark pencils in the plane of polarisation, while actually light ones are observed, probably rests on a misunderstanding, as Jamin(1) especially remarks that his calculation yields a yellow colour in the plane of polarisation.

Haidinger now thinks that he may assume that the small globules which, according to a communication from Wedl, exist in the anterior layer of the lens, reflect the polarised light in such a manner that the formation of the pencils may be deduced from this fact. He states, that it is just that light which strikes the anterior surface of a globe at the angle of polarisation, which is transmitted from it to the posterior surface of a second globe, and from it to the retina, if the plane of incidence at the first globe coincides with the plane of polarisation. On the other hand, he supposes that a minimum of light must occur perpendicularly to the plane of polarisation, and that thence the pencils arise.

**Defective Sight.** — A clergyman, Schnyder(2), at Menzberg (Lucerne), communicates that he is far-sighted for horizontal, short-sighted for vertical lines, and that he has corrected the fault by a combination of cylindrical convex lenses placed horizontally with ordinary concave spectacles.

Stokes(3) has constructed an apparatus with which that form of lens can be determined, which improve such eyes, as have a spherocylindrical, instead of a spherical curvature.

**Achromatopsy.** — D'Hombres Firmas(4) has given an enumeration of several cases of achromatopsy, that is, of the inability to distinguish colours.

(1) Pogg. Ann. LXXIV, 146.

(2) Arch. Ph. Nat. X, 302; from Verhandl. der Schweiz. Naturf. Gesellsch, 1848, 15.

(3) Instit. 1849, 350.

(4) Compt. Rend. XXIX, 175.

Photography.  
Theory of  
the daguerreotype  
process.

**Photography. Theory of the Daguerreotype Process.**—We have remarked, in the last Annual Report(1), that Claudet has attempted to explain the different results obtained by various inquirers in reference to the continuing and destructive action of the different coloured rays of the spectrum. He now, in a more extensive treatise(2), expresses himself more definitely on the subject. He finds that light gives bromo-iodide of silver in an extremely short period of time, in about  $\frac{1}{100}$  of a second, an affinity for mercurial vapours; the bromo-iodide of silver is not decomposed by this action, for the effect of the irradiation can easily be neutralised by red, orange-coloured and yellow rays. He states that this effect, upon which the true daguerreotype process is based, differs from another which takes place in a much longer period, from 2 to 3 seconds, and which consists in a decomposition of bromo-iodide of silver, the silver being separated in the shape of a white, and, as it appears, crystalline powder; in this manner also Gaudin(3) has found the employment of light alone causes a positive image which is not destroyed by hyposulphite of soda, as the white powder is not soluble in this medium. It is well known that in the daguerreotype process the parts that are impinged upon by the light are blackened, or that a negative image is produced, which is only rendered positive by the application of mercurial vapours.—Claudet, moreover, states that a silver plate, which is only prepared with iodine without the addition of bromine, exhibits a different deportment from one prepared with iodide of bromine, inasmuch as the red, orange-coloured and yellow rays, do not neutralise, but increase the affinity to mercurial vapours, which is communicated by the white light (or the chemical rays contained therein,) as well as the decomposing action occurring after continued irradiation. Still, if the iodising process is continued longer(4), a silver-compound containing more iodine is said to result, which is generally more susceptible, and also analogous to the bromo-iodide of silver in reference to the processes described.—Claudet states, in explanation of this difference in the deportment, that iodide of silver without bromine, is 100 times more susceptible to the decomposing influence of luminous rays than bromo-iodide of silver, whereas it is 100 times less susceptible than the latter of the action which causes the affinity for mercurial vapours. The red, orange and yellow rays, therefore, when pure iodide of silver is employed, meet with an incipient decomposition, which they continue, even if a short operation of white light has preceded.—“It therefore appears,” says Claudet, “that all the different rays possess the property of decomposing the iodide of silver in a longer or shorter space of time, as well as of

(1) Annual Report for 1847 and 1848, Vol. I, 172, 173.

(2) Phil. Mag. [3] XXXV, 374; Instit. 1849, 382; Ann. Chem. Pharm. LXXII, 173.

(3) Annual Report for 1817 and 1848, Vol. I, 172.

(4) Ibid. 173.

communicating to bromo-iodide of silver an affinity for mercurial vapours. There is, however, this difference, that in employing the first compound the effects of the different rays are continued, whilst in the second, they are neutralised."

Photography.  
Theory of the daguerreotype process.

Claudet observes, that practical artists are exposed to very great disappointments in regard to the luminous effect of the atmosphere, because the most luminous rays are entirely distinct from those which possess the greatest chemical power. One half of a picture was covered with a dark blue, the other with a light yellow glass, so that the former became invisible, and the latter remained very distinctly visible; the half covered with the blue glass was distinctly represented by the daguerreotype apparatus, whilst the other gave no image. Claudet, therefore, repeats his recommendation of his photographometer(1) for the purpose of determining the chemical power of daylight; he has improved it by introducing in the fixed metallic plate, instead of one horizontal row of seven round apertures, four or eight such rows, which may be closed by the first, second, fourth (and so on), descent of the sliding plate. The chemical action which is thus produced upon the points of the susceptible plate lying under the apertures, form a numerical scale of from 1, 2, 4 . . . to 512, when 4 horizontal rows, or of 1, 2, 4 . . . to 8192 when 8 rows are employed. The measurements above quoted were made with this instrument.

Claudet observed in his photographic studies, that even in achromatic lenses the photogenic did not coincide with the optical focus, *i. e.*, the visual focus; but in one system of lenses lay before, in the other behind it.—We can scarcely believe that Claudet should only have ascertained the easily intelligible reason of this phenomenon from Lerebours(2), as it must be evident to everybody that this phenomenon can only be caused by an incorrect relation between the foci of both lenses, or an imperfect achromatism which is not calculated for the chemical rays. Claudet remarks that he prefers operating with lenses whose spherical aberration is entirely corrected at the expense of a more perfect achromatisation, because he thus obtains a more defined image, and in a period which is shorter in proportion as the less refrangible rays are, on account of their foci becoming more distant, less capable of diminishing the effect of the chemical rays; it appears that there is an error in regard to the first point, *viz.* the spherical aberration, as achromatisation is well known to depend only upon the relation of the focal distances, while even for the most perfect correction of spherical aberration, the radii of curvature may still be taken arbitrarily. There is, however, no doubt that sepa-

(1) Annual Report for 1847 and 1848, Vol. I, 180.

(2) As stated by Claudet (Phil. Mag. [3] XXXV. 382).



Photo-  
graphy.  
Theory of  
the da-  
guerre-  
type pro-  
cess.

rate calculations are necessary to determine the achromatism of lenses destined for optico-chemical purposes.—Claudet communicates a method invented by Knight for the determination of the chemical focus(1). It consists in ascertaining first the optical focus, or the point of the best defined image, with the glass plate; an iodised silver plate is then introduced vertically in the frame in which the glass plate is fixed, but inclined to the axes of the instrument, in such a manner that its plane cuts the glass plate in the middle of the field of vision in a vertical line. If a printed sheet be chosen as an object, it becomes very apparent how far the chemical falls before or behind the optical focus, as a defined image is formed at the corresponding point of the silver plate alone. The plate is provided with a scale from which the distance can be read off, to which the system of lenses must be advanced or withdrawn, in order that the chemical focus may occupy the place where previously the optical focus lay.—Claudet moreover thinks that he has discovered the distance of the foci of the visible and chemical rays to be extremely variable, even when the same lenses are employed, and there is the same distance of the object. At first he sought the explanation in the variations of the optical state of the atmosphere, as the increase or diminution in the number of yellow rays necessarily displaces the point of greatest chemical action. But it was proved that the changes in the interval between the optical and the chemical focus, varied very much at the same time in two sets of lenses, in both of which the chemical focus lay behind the optical focus. When the foci of one set were at the greatest distance, those of the other were close together, or coincided; in some cases they coincided at the same time in both lenses.—It is evident that we here meet with two alternatives; either the preparation of the plate decides which rays act most effectively, or the last quoted results of Claudet are merely the expression of errors of observation.

**Photographic Pictures on Paper.**—In the last Annual Report(2) we communicated that Niepce de St. Victor employed a thin layer of albumin, which had been previously mixed with nitrate of silver, as a substance sensitive of light, for the purpose of fixing photogenic pictures on glass. Blanquart-Evrard(3) now describes a method which serves to produce the negative picture (*matrice*) on a thin lamina of albumin, which is preferable to paper on account of its greater transparency. These negative pictures are stated by Blanquart-Evrard to remain unchanged by light; they lose none of their properties after an unlimited number of copies have been taken, they may be repaired when they have suffered injury, and yield good results at all tempera-

(1) Phil. Mag. [3] XXXV, 384.

(2) Annual Report for 1847 and 1848, Vol. I, 179.

(3) Compt. Rend. XXIX, 215; Instit. 1849, 265; Ann. Ch. Pharm. LXXII, 178.

tures, and however illuminated. They are obtained in the following manner: a certain quantity of albumin is put in a deep vessel, the solid opaque constituents are removed, and every source of impurity is carefully avoided. 15 drops of a saturated solution of iodide of potassium are added, the albumin beaten up into a froth, and then allowed to stand until it has again become liquid. The glass plate which is to be employed is then cleaned with alcohol, and placed upon a tray over which it projects; a sufficient quantity of albumin is then poured upon it, and a piece of plate-glass passed several times over the surface in order to bring the albumin throughout into such close contact with the glass, that there may remain a layer when the plate is raised at one corner, to let the liquid albumin run off. The plate is then placed horizontally and dried.—When the albumin has become perfectly dry, the plate is exposed to a high (or also with the same effect to a very low) temperature, until the layer of albumin appears full of fissures. In order to bring the whole surface at once into contact with the solution of silver(1), the solution is poured to the depth of about half a centimeter, into a flat vessel with a smooth bottom; the vessel is inclined at about  $45^{\circ}$ ; the plate with the layer of albumin downwards is introduced with one edge, and both plate and vessel are then suddenly restored to the horizontal position. The plate is immediately taken out, well rinsed in water, and the fluid allowed to run off by taking hold of one corner, and forcibly striking the other.—The plates that have been thus prepared, may be employed moist or dry; after the light has been allowed to take effect in the camera, the pictures may be at once developed, or only after a lapse of time. For this purpose the plate is introduced into a saturated solution of gallic acid, to which a little nitrate of silver dissolved in acetic acid is added. It is well to take the plate out of the gallic acid, before the picture has assumed the full tone, as it is easy to strengthen it by repeated immersion, while nothing can be removed after the tones have once been rendered too dark. The plate is then washed in water, passed through a solution of bromide of potassium (30 grm. to 100 grm. of water), again washed and dried in a horizontal position in the dark chamber. The albuminous layer thus attains hardness and firmness, so that if the glass plate be required for other purposes, the albumin can only be entirely removed by strong chemicals, such as cyanide of potassium. The positive pictures are taken from these pictures in the same way as they are taken from negative pictures on paper.

C. Brooke(2) describes an improved method of preparing paper

(1) Blanquart-Evrard uses the solution of nitrate of silver in acetic acid for this purpose. (See Annual Report for 1847 and 1848, Vol. I, 175).

(2) Chem. Gaz. 1849, 412; Instit. 1849, 408; Ann. Ch. Pharm. LXXII, 181 (in abstr.).

Photo-  
graphic  
pictures  
on paper.

destined for photographic self-registration(1), which must therefore serve for an effect that endures for a considerable period.

A. Martin(2), who receives pecuniary aid from the Imperial Academy of Sciences of Vienna for the purpose of perfecting the methods of photography, has observed that the best process for obtaining paper which is to serve for photographs, consists in dipping it first in a solution of iodide of potassium, and then to brush it with a solution of nitrate of silver; it then becomes more sensitive for the soft gradations of the semi-tones, than if the solution of silver had been applied before the solution of iodide of potassium.—A less saturated solution of gallic acid is said to afford stronger pictures than the concentrated solution recommended by Blanquart. Martin especially ascribes to his method of fixing, the advantage of yielding very clear, transparent, and strong pictures. This method consists in first washing the picture with a little spirits of wine, and then introducing it into a boiling solution of hyposulphite of soda. Martin's directions in reference to the several liquids are as follows: I. *Negative Picture*—1)  $\frac{1}{2}$  oz. iodide potassium in 10 oz. of distilled water, with 8 to 10 drops of a concentrated solution of cyanide of potassium; 2) 7 drachms of nitrate of silver dissolved in 10 oz. of distilled water, with two drachms of strong acetic acid; 3) concentrated solution of gallic acid; 4) spirits of wine; 5) 1 oz. of hyposulphite of soda dissolved in 10 oz. of distilled water. II. *Positive Picture*—6) 168 grains of chloride of sodium dissolved in 10 oz. of distilled water; 7) 1 oz. of nitrate of silver dissolved in 10 oz. of distilled water; 8) 1 oz. of hyposulphite of soda dissolved in 10 oz. of distilled water, and mixed with a solution of from 30 to 40 grains of nitrate of silver in  $\frac{1}{2}$  oz. of water. The solution of silver is poured in a thin stream into the solution of soda, while the latter is constantly stirred.

We refer to the place above quoted for the very detailed descriptions given by Martin of the mechanism of photography.

**Coloured Photogenic Pictures.**—E. Becquerel has described the method of preparing coloured photogenic pictures announced last year(3) more in detail(4); there is, however, but little of novelty or importance to be derived from the extended exposition. The best mode of preparing the silver plate consists in placing it in water acidulated with hydrochloric acid (125 cub. centimeters of ordinary hydrochloric acid to 1 litre of distilled water), making it the positive pole of a voltaic battery, so that chlorine in the nascent state is brought into

(1) Annual Report for 1847 and 1848, Vol. I, 176.

(2) Wien. Acad. Ber. 5, Hft. 81; Ann. Ch. Pharm. LXXII, 180 (in abstr.).

(3) Annual Report for 1847 and 1848, Vol. I, 174.

(4) Ann. Ch. Phys. [3] XXV, 447; Pogg. Ann. LXXVII, 512; J. Pr. Chem. XLVIII, 154; Arch. Phys. Nat. XI, 34 (in abstr.); Ann. Ch. Pharm. LXXII, 176; Regnault's report thereon, Compt. Rend. XXVIII, 200; Instit. 1849, 67.

contact with the plate. In the space of a minute the plate passes from grey, yellowish, purple to bluish and greenish; then again through grey, rose-colour and violet to blue. The operation is broken off before this second blue occurs, or when the violet-red appears; the plate is washed with distilled water, and dried over the spirit-lamp while the operator blows on the surface. The plate when thus prepared presents a dark violet colour, is extremely sensitive, and must, therefore, be preserved in the dark. Before use the surface is polished with a cotton ball. If a solar spectrum of 4 to 5 centimeters in length is thrown upon it, a pale picture, coloured like the spectrum, is obtained if the illumination is weak and rapid. If the light be allowed to operate longer, the red is first formed more strongly, and soon becomes dark, as outside the line A a dark puce, or amaranth, is formed. Orange and yellow are less prominent; green, blue and violet form the most beautiful parts of the spectrum; external to the line H, where the spectrum exhibits a delicate lavender-grey, a grey band is formed.—Becquerel also found that the sensitiveness of the plate for various coloured rays may be modified by heating it. It is best to heat it to  $100^{\circ}$ , so that the plate assumes a rather reddish colour; a metallic bath of lead and tin also answers the purpose well. A plate thus treated renders all the colours of the spectrum, even yellow, well. If instead of a round opening a fine slit is employed, which receives light through a heliostat, even the stronger lines of Fraunhofer, viz., A, B, C, F, H may be obtained on the plate, but on account of the light being attenuated a longer period, about 1 to 2 hours, is required for the effect. By a screen of from 1 to 2 centimeters in thickness, of a solution of sulphate of quinine, all rays beyond the line H in violet, may be intercepted, so that the image of the spectrum appears well defined at this side.—In order to obtain the hues of coloured glasses, heated plates must be employed, and a solution of sulphate of quinine introduced as a screen; still the colours remain weak, and have a tinge of violet, on account of the proper colour of the sensitive substance. If the colour of the glass be decomposed by a prism, the points of the sensitive plate corresponding to the dark spaces of the spectrum, remain unaltered.

If a coloured engraving be placed upon the prepared plate, the printed side being turned to the plate, a glass plate and a screen of sulphate of quinine in solution superimposed upon this, and the whole exposed to solar light, the drawing as well as the colouring are pretty well transferred. The pictures of the camera obscura require a very long time (from 10 to 12 hours under the most favourable circumstances) for producing a sufficient effect. Becquerel, however, succeeded in producing a few pictures with beautiful colours. Landscapes never succeeded, probably on account of the small intensity of the green light.—We have formerly stated that the photochromatic

Magnet-  
ism.  
Sustaining  
power.

pictures are destroyed by a continued action of light, and that Becquerel has not as yet succeeded in fixing them(1).

**Magnetism. Sustaining Power.**—The following deductions, founded on experiments made with the view of ascertaining the sustaining power of electro-magnets are communicated by Oerstedt(2), who was assisted in this investigation by the candidate Holten. The propositions themselves contain nothing which is essentially new.

1. The amount of the sustaining power of an electro-magnet is dependent upon the magnitude of its armature.

2. The magnetic sustaining power of the magnet, when in direct contact with the armature, does not increase uniformly with the magnetism developed on the whole surface of the electro-magnet.

3. But if there be a distance between the two mutually attracting surfaces, the attraction is increased with the intensity of the developed magnetism, and the increase is in proportion to the distance.

**Magnetising of Steel Bars.**—Several years ago Elias(3) of Haarlem, discovered an effective method of magnetising steel bars, which is now well known. This operation is effected by moving repeatedly backwards and forwards the bar to be magnetised through a helix of thick copper wire, which is traversed by a powerful electric current. Frick, of Freiburg(4), has recently compared this method with that of the touch. In this comparison he employed an electro-magnet which was surrounded by an amount of wire not greater than is requisite for the spiral prepared after Elias's direction. When the currents produced by these two methods are of equal intensity, he prefers, on the whole, the action of the electro-magnet, but admits that the difference between the two methods gradually diminishes when a current of greater intensity is employed. His helix was broader and not so high as that described by Elias, and it was composed of a less number of coils. It is nevertheless probable that if more powerful currents had been applied, a superiority in favour of the helix might have been established by Frick's experiment, if he had taken the precaution of uniting both ends of the bar during the process by an armature of soft iron, as had been recommended by Elias. For this method of magnetising is, as the latter physicist very justly remarked in his first treatise, only a modified, although really an improved, means of performing the operation of the double touch. The advantage

(1) Annual Report for 1847 and 1848, Vol. I, 174.

(2) From Arch. for Pharm. och technisk Chem. II. 1, in Jahrb. pr. Pharm. XVII, 284 (in abstr.).

(3) Pogg. Ann. LXII, 249; LXVII, 356.

(4) Ibid. LXXVII, 537.

of the helix consists not only in preventing intermediate poles from being formed, but also in simultaneously affording the possibility of effecting a magnetic induction of great intensity on all points of a very small zone, around the steel bar. The band-spiral recommended by Böttger(1) (coiled, however, only in one direction), has the merit of greater simplicity than the above, and farther admits of obtaining the required amount of inductive power with the smallest amount of copper. By a band-spiral of copper weighing  $4\frac{1}{2}$  lbs., 1 millimeter thick and 20 broad, a 6 lb. bar of very hard cast-steel, when its poles were united with an armature of soft iron, was magnetised to saturation as completely as it could be accomplished by any known process of communicating permanent magnetism, merely by passing the spiral once backwards and forwards along the bar. The same bar without the aid of the armature, even if the spiral was passed over it many times, did not assume more than 0.6 of this power.

In direct contradiction to these experiments, and to many others of a similar kind, both of an ancient and a modern date, Sinstedden(2) asserts that the application of an armature during the process of magnetising a steel bar, if the object be to communicate the highest possible condition of permanent magnetism, is rather detrimental than conducive to this state. As Sinstedden adduces no direct proof of the correctness of this opinion, it may be regarded rather as a theoretic assumption than as a fact actually established on experimental evidence. In the mode of magnetising compound horse-shoe magnets, proposed by himself, he by no means omits to avail himself of the principle of the armature(3). In order to prevent as much as possible the very considerable loss of magnetic force, by the free magnetism returning to the neutral condition, while uniting the different individual magnetised laminae, Sinstedden considers it expedient to magnetise the steel laminae while in conjunction. He places the compound horse-shoe magnet with the poles directly opposite to the poles of a powerful electro-magnet, and in such a position that the mutual polar surfaces may exactly come into contact. If the polar surfaces of the steel magnet are longer than those of the electro-magnet, he introduces two thick iron plates of the size of the polar surface of the steel magnet, between the opposite poles of both; the galvanic circuit is then closed in such a manner that the pole of the electro-magnet which is in contact with the pole of the steel magnet marked N, becomes the south pole. The maximum of magnetic development, it is stated, is only attainable by repeatedly opening and closing the circuit. While it is closed both limbs of the electro-magnet are frequently touched by a thick piece of iron from the bend towards the two poles.

(1) Pogg. Ann. LXVII, 115.

(3) Ibid. LXXVI, 195.

(2) Ibid. LXXXVI. 40.

Magnet-  
ising of  
steel bars.

It is not easy to conceive why the same object might not be as effectually attained, and, in truth, with greater certainty, when the operator has not the command of very powerful electro-magnets, by putting together the steel lamellæ, saturated and still armed, and by then cautiously removing the single armatures.

A state of super-saturation can be permanently retained in a magnet, by means of a small iron rod laid across its limbs, and attached to them. A large portion of this excess of power may, according to Sinstden's experience, be used for increasing the sustaining power, and especially for induction in electro-magnetic machines.

**Coercive Power.**—C. Woestyn(1) has observed that a pole of a magnet can be attracted, and indeed held fast by the similar pole of another magnetic bar, without either the one or the other losing its polarity. He states *inter alia*, that a well-tempered bar magnetised to saturation and suspended as a needle, was attracted by a strong magnet (similar poles being in opposition) at 3 centimeters' distance, without the subsequent inversion of its poles. Under similar circumstances he produced in a magnetic rod a transient intermediate pole, which he proved by strewing the bar with iron-filings.

In reference to these experiments it cannot be considered irrelevant to state that they are valid only within certain limits, viz., in so far as the power of the one magnet is insufficient to overcome completely the coercive power of the other.—Woestyn arrives at the conclusion that steel magnets are composed of parts which have coercive power, and of softer parts without coercive power, and that in his experiments the polarity of the former may have been covered by a transitory polarity of the latter. He also conjectures that the effect of tempering may be limited chiefly to the external parts of the steel bar.

In connection with this observation Zamminer and Buff have obtained a result, from which it appears that under the influence of weak electric currents, the polarity of magnetic bars, even when well-tempered, can be increased, diminished, and, if the development of magnetism be inconsiderable, even reversed, without the derangement of the original polarity, after the current has been interrupted. A thin cylindrical shell of well-tempered steel, when submitted to a weak electric current, assumed magnetic polarity, which it lost again on the cessation of the current. Under a current of equal intensity, the polarity was more than doubled by introducing into the shell a short piece of iron, in such a manner, that its ends were at a distance of an inch from both extremities of the shell. Hence it cannot be doubted that the activity of the magnetic force pervades such masses of iron,

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(1) Compt. Rend. XXVIII, 289; Ann. Ch. Phys. [3] XXVI, 520.

the coercive power of which it cannot surmount, in the same manner as it would pass through any non-magnetic substance.

Magnetic  
power of  
stones and  
rocks.

**Magnetic Power of Stones and Rocks.**—Delesse(1) tests the magnetic properties of various substances by placing them in greater or smaller pieces, and even in a pulverised condition, between the poles of a powerful horse-shoe electro-magnet, upon which two cylindrical half armatures can move towards each other, so that their vertical edges may come into immediate contact. If a body possess only the least magnetic power, its particles when finely divided will be attracted and suspended chiefly along the line of contact of the two pieces of armature. By this method Delesse confirms the experience of other physicists, that not merely substances containing iron, but mineral constituents of every kind entering into the composition of the earth's crust, some in a higher, others in a lower degree, are all susceptible of magnetic polarity.—In order to estimate the relative amount of magnetic force in different bodies, they were reduced to a uniform and impalpable powder, and were then placed in proximity with the terminal surface of a magnetic bar. Delesse considers the weight of the particles so sustained as proportional to their magnetic properties, and hence assumes this weight as an expression of the magnetic power of the substance under examination. He finds thus, *e. g.*, the magnetic power of iron equal to that of steel, cast-steel 66 per cent of that of steel, that of nickel 35 per cent, of the richer sorts of iron slag from 2 to 3 per cent., &c. &c.—The communications of Delesse have reminded Durocher(2) of his earlier investigations on the same subject(3). According to the latter, the magnetism of rocks, is chiefly dependent on three conditions, viz., the quantity of iron which they contain, the relative amount of sesquioxide and protoxide of iron in their composition, and the manner in which these oxides are combined with the constituents of the rock.

**Magnetism of Steam.**—Reuben Phillips believes that he has discovered that an electric current is produced by a jet of steam from a hydro-electric machine, when it is surrounded by a closed spiral coil; and hence he concludes that steam possesses magnetic power. This deduction, however, requires farther confirmation(4).

**Disturbing Influences on the Direction of the Magnetic Needle.**—Several physicists have asserted, that chains of mountains and individual hills can produce local disturbing effects on the strength and

(1) Compt. Rend. XXVIII, 35, 227, 437, 498, 589; Ann. Ch. Phys. [3] XXV, 194; XXVI, 148; Instit. 1849, 27, 76, 106, 121; Ann. Min. [4] XIV, 81; XV, 497; Arch. Ph. Nat. X, 207, 235; XI, 134.

(2) Compt. Rend. XXVIII, 589; Instit. 1849, 145.

(3) Annual Report for 1847 and 1848, Vol II, 445.

(4) Phil. Mag. [3] XXXIV, 502; XXXV, 490; Instit. 1849, 293; Arch. Ph. Nat. XII, 308.



Disturbing  
influences  
on the di-  
rection of  
the mag-  
netic  
needle.

direction of the terrestrial magnetic force. In order to arrive at some decisive results on this head, F. Reich(1) made a series of observations on the direction of the magnetic needle in a number of positions around the Pöhlberg, a basaltic hill in the vicinity of Annaberg, where individual blocks of basalt show clear indications of magnetic activity. Reich found, nevertheless, that such a magnetic polarity, as can effect any considerable disturbance on the directive power of the needle, does not exist in the hill, or at all events, only to a very insignificant extent.

**Variation in the Direction of the Magnetic Needle.**—Quetelet(2) communicates observations which have been made in the observatory of Brussels, according to which, since October, 1827, to March, 1849, the direction of the declination-needle has varied from  $22^{\circ} 28' 8''$  to  $20^{\circ} 39' 2''$  towards the west, and the direction of inclination (dip of the needle) from  $68^{\circ} 56' 5''$  to  $67^{\circ} 56' 8''$ .

**Non-existence of a Line without Daily Variation of Declination.**—The direction of the magnetic needle, as is well known, is subject to very regular variations, which are of daily occurrence. The north pole of the horizontal needle in Europe, from the hours of  $1\frac{1}{4}$  P.M. to 7 or 8 o'clock the next morning traverses from west to east, and between the hours of 8 A.M. and 1 P.M. retraces its course towards the west. This motion occurs in the same manner during every month of the year, but it is rather greater in summer than in winter. A similar deportment has been observed in North America, and generally in middle latitudes of the northern hemisphere. In middle latitudes of the southern hemisphere, however, exactly opposite variations appear contemporaneously. From these phenomena it has been conjectured that somewhere in the vicinity of the equator, there must exist a line which is not affected by daily variation.

With reference to this opinion, Sabine(3) gives the following statement as the result of observations at St. Helena, extending over a period of five years. A peculiarity of the daily variation of the needle is clearly perceptible; it consists in this, that during the one-half of the year (the summer of the northern hemisphere), the motion of the north-pole of the needle, at the same hours, corresponds with the direction which it assumes in the northern hemisphere; and, on the contrary, its tendency during the other half of the year, coincides with the direction prevalent in the southern hemisphere. The transition from the one order of motions to the other occurs at the equinoxes, or soon afterwards. Hence it appears, that the supposed line of no daily variation of the needle does not exist.

(1) Pogg. Ann. LXXVII, 32.

(2) Instit. 1849, 204.

(3) Phil. Trans. f. 1847, I, 51; Pogg. Ann. LXXVIII, 494; Phil. Mag. [3] XXXIV, 466.

**Hypotheses on the Causes of Daily Variation.**—Several new hypotheses have been promulgated to explain the daily variation of the needle. Lamont(1) considers that it is not an improbable supposition that the sun is a uni-polar electric body, *e.g.* charged with a great amount of positive electricity. In this case it would exert an inductive action on the mass of the earth in such a manner, that the hemisphere exposed to the sun would be charged with negative, and the opposite side with positive electricity. By means of the earth's rotatory motion, a current of electricity would be thus produced moving round the earth in 24 hours. The current thus produced is not, however, likely to be confined to the surface of the earth, for Lamont endeavours to prove, both by calculation and by observations of his own, that the magnetic variations cannot be ascribed to any magnetic, galvanic or thermo-electric power excited on the surface of the earth, if it be admitted that such a power obeys the general laws of magnetism.

Hypotheses on the causes of daily variation.

Barlow(2) establishes a connexion between the oscillations of the declination-needle and the daily, regular, electric variations, the existence of which in the earth he has observed by the aid of telegraphic wires very favourably situated. He states that Derby is the centre of four telegraph lines, the Northern uniting it with Leeds, the North-Eastern with Lincoln, the Southern with Rugby, and the South-Western with Birmingham. In all of these lines there are frequently manifested disturbing natural electrical currents which, when considered individually, showed that when the current in the two first-mentioned lines moved towards Derby, that in the two latter travelled in an opposite direction, and *vice versa*. These natural currents are, Barlow asserts, always perceptible in every wire, whose two extremities are united at a considerable distance by plates under ground. The strongest action is, however, observed when the straight line of union between both the immersed plates is exactly in the direction of north-east to south-west. In this case the direction of the conducting wire is of no importance.

Two delicate galvanometers, attached to the two extremities of a wire 41 miles in length, simultaneously indicated, by the direction of the deflection, a similar change both in the intensity and direction of the natural current; and by the nature of the oscillation, to which the needle is subject, a certain regularity in the motion of the current could be inferred; it seemed as though its direction from morning to evening differed from the direction it exhibited from evening to morning. The period of change in which the needle passed through zero

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(1) Pogg. Ann. LXXVI, 67.

(2) Phil. Mag. [3] XXXIV, 344; Arch. Ph. Nat. XI, 299 (in abstr.).

Hypo-  
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varied from 7 to 10 o'clock both in the morning and evening. These regular daily motions were subject to perturbations of less or greater intensity, and of longer or shorter duration, and frequently were so powerful as to impede the usual transmissions through the telegraph. The appearance of an aurora borealis during its continuance, exerted a disturbing influence of uncommon energy.

During that part of the day when the direction of the current through the earth was southerly, the needle of a declinometer showed a western deviation. During the night and part of the morning, when the current passing through the earth assumed a northern course, the deflection of the needle changed in an eastern direction. The uncommon and more powerful disturbances also were observed simultaneously in the declinometer and galvanometer. Barlow seems to regard the current passing through the wire as a branch of the natural terrestrial current, although he does not clearly express this opinion. This opinion is, however, supported by the observation which he communicates, that the phenomena in wires under ground and in those in the atmosphere were of the same kind, and hence he concludes that the current passing through the wires cannot be derived from atmospheric electricity. He considers that thermo-electric influences, which are produced by the unequal temperatures in the earth, are the probable cause of this phenomenon. This is tantamount to saying, that he has not as yet discovered the true cause.

De la Rive(1) also explains the daily variations of the magnetic needle by thermo-electric influences, which, however, according to his opinion, take place in the atmosphere. "It is known," he says, "that in all bodies whatever, when heated at one end and remaining cool at the other, the positive electricity proceeds from the warm to the cold side, and *vice versa* the negative from the cold to the warm. Hence it follows that the lower and warmer layer of a column of atmospheric air must be constantly negative, and the upper and cooler layer must be positive.—If we admit this conclusion which, unsupported as it is by experimental proof, can only be regarded as a bold assumption, both electricities must be simultaneously generated everywhere in the atmosphere. The negative electricity existing in the lower atmospheric regions is constantly abstracted by the moist ground which is an excellent conductor, while the positive existing in the superior strata extends, and, as we are taught by experience, increases in intensity towards the still higher parts of the atmosphere, until partly through moisture, rain and snow, which reconduct it down to the earth, and partly through

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(1) Ann. Ch. Phys. [3] XXV, 310; Phil. Mag [3] XXXIV, 286; Arch. Ph. Nat. X. 297 (in abstr.).

normal causes which are in continual operation, an equilibrium between both is restored. This normal cause, De la Rive supposes to be an electric current present in the upper rarified regions of the atmosphere, which moves from the equator towards the poles.

Hypotheses on the causes of daily variation.

The existence of such a current is now generally admitted, although on very different grounds from those advanced in support of the above hypothesis which is based on no experimental evidence whatever. For as the warm air rising in the zone of the trade-winds, does without doubt contain electricity, from whatever source it may be derived, it is evident that also the upper poleward current must be more or less charged with electric matter which is, by the winds that prevail on both sides of the equator, impelled towards the poles. De la Rive farther asserts, that this electricity is sooner or later conveyed downwards through moist layers of atmospheric air upon the earth, especially in the cold polar zones, whereby an electric circulation is established, which passes from the equator to the poles through the higher regions of the atmosphere, returning to the equator below the surface of the earth. De la Rive supposes that the intensity of this current changing from day to night is the cause of the daily variation of the magnetic needle.

In the highest strata of the atmosphere, and especially in winter and in the polar circle, the air is filled with minute floating particles of ice and snow forming a sort of semi-transparent cloud which is an imperfect conductor; the two electricities when accumulated in considerable force are mutually transmitted with the emission of flashes which illuminate the icy particles. This, according to De la Rive, is the origin or cause of the northern-lights. The explanation of the aurora by the electricity which passes from the equator towards the poles, and by the electric discharges among the thin feathery clouds in the polar regions where no thunderstorms occur, is by no means new. Ever since the electric light has been observed in the rarified space, the same view has been advanced by many physicists; as, for example, by Bertholon de St. Lazare, and even by Franklin(1).

In reference to a suggestion of Morlet(2), that this hypothesis regarding the origin of the aurora would become very probable, if by direct experiment an influence of magnetism on the electric light could be proved, De la Rive has communicated the following very remarkable experiment(3).

An iron bar, covered entirely, excepting the surfaces of its two

(1) Gehler's Phys. Wörterbuch. Neue Bearb. VII, 239, 240.

(2) Ann. Ch. Phys. [3] XXVII, 65.

(3) Compt. Rend. XXIX, 412; Instit. 1849, 329; Arch. Ph. Nat. XII, 222.

Hypotheses on the causes of daily variation.

extremities, with a thick coating of wax, was half enclosed in a hermetically-sealed glass globe. The waxed bar was held within the globe by a copper ring passing over the wax, which approached as closely as possible to the inner side of the glass. A wire formed a communication between the ring and the outside. After the globe was exhausted, the wire was united with one of the conductors of an electric machine, whilst the external end of the rod was in contact with the other, or with the earth. The ordinary current of electricity *in vacuo* was thus produced. But when the iron bar was touched with the pole of a strong electro-magnet, then the electric luminous current, issuing only from the margin of the free iron surface, assumed the form of a connected ring, revolving round the bar either to the right or to the left, in accordance with the direction of the discharge and of the magnetic polarity thus developed. De la Rive considers this phenomenon as analogous to that of the northern-light in the vicinity of the terrestrial magnetic poles, which he regards as the centres of similar rotatory luminous currents, viz., of the aurora borealis.

**Evolution of Heat by Magnetism.** — Grove(1) has observed, that heat was produced while an iron bar was alternately magnetised and demagnetised. For this purpose he employed an electro-magnet of the horse-shoe form which he immersed into cold water up to the two poles, in order to exclude the effect of the heat derived from the coil of wire; its armature which was just above the water was moreover surrounded with bad conductors. On passing an intermittent current through the coil, whereby a magnetic induction was alternately produced and suspended in the armature, the temperature of the latter was increased to the amount of some degrees, whilst the horse-shoe was somewhat cooled under the influence of the cold water. Grove attributes this evolution of heat to the friction of the iron particles on each other, which he assumes to be in a state of vibration round the magnetic axis.

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In reference to the action of magnetism on polarised heat see page 33.

**Action of Magnetism on Polarised Light.** — Bertin(2) communicates the following statements on the magnetic polarisation of light: 1. When glasses are so changed in their molecular condition through tempering, heating, or pressure, that they show lively colours in polarised light,

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(1) Proceedings of the Royal Society, May, 1849, Pogg. Ann. LXXVIII, 567 (in abstr.); Arch. Ph. Nat. XI, 210.

(2) Compt. Rend. XXVIII, 500; Instit. 1849, 123.

these colours, under the influence of an electro-magnet, are subject to no change. 2. The plane of polarisation of light which, in the interior of Fresnel's parallelopipeds had four times undergone total reflection, is not farther changed by the influence of the current. The only effect of the current in this case is an increase or decrease of the partial depolarisation to which the polarised light is subject in total reflection. If from the plane of reflection the circle be divided into 8 octants, the action of two opposite currents is of the greatest intensity, and in the same direction at an azimuth of  $0^\circ$ ,  $90^\circ$ ,  $180^\circ$ ,  $270^\circ$ , and the action is zero, at  $45^\circ$ ,  $135^\circ$ ,  $225^\circ$ ,  $315^\circ$ ; at  $22^\circ 5'$ , and so on, advancing by octants, the action of both currents is opposite, and the difference at the same time is at its maximum.

Evolution  
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**Diamagnetic Phenomena.**—During this year the investigations on diamagnetism are almost exclusively confined to the facts first observed by Plücker(1), viz., the phenomena which are presented by crystallised bodies placed between the magnetic poles.

This physicist has the merit of the most important discovery made in this department, which consists in the fact(2) that the optic axis of crystals is not *always* repelled from the poles, as he formerly supposed, but that the axis of the optically-negative crystal is repelled, whilst that of the positive is attracted(3.) In the uni-axial crystals this has reference to the axis itself, and in the bi-axial to the middle line, which bisects the acute angle of the optic axes. Among the positive crystals this phenomenon is very clearly exhibited by *diopside*, and among the negative by *cyanite* and *topaz*. As the middle line of these crystals makes an angle  $\alpha$  with the axis of the prism, the latter, according to the manner of suspension, can assume all positions which coincide with a conical surface described about the middle line with the angle  $\alpha$ , whilst the axis of the cone in the positive *diopside* has an axial, in the negative *cyanite* and *topaz* an equatorial position. *Cyanite* even obeys the impulse of terrestrial magnetism, and as in this case the same end is directed always towards the north, Plücker believed himself entitled to assume a polarity of the opto-magnetic force.

In reference to their magnetic behaviour, Plücker(4) has examined the following crystals :

(1) Annual Report for 1847 and 1848, Vol. I, 192.

(2) Phil. Mag. [3] XXXIV, 450; Pogg. Ann. LXXVII, 447; Sill. Am. J. [2] VII, 270; Instit. 1849, 272; Arch. Ph. Nat. XI, 196; Ann. Ch. Pharm. LXXII, 191—193.

(3) Knoblauch and Tyndall state (Pogg. Ann. LXXIX, 223; Phil. Mag. [3] XXXVI, 178; Arch. Ph. Nat. XIII, 319) that they have found (1850) the optical axes of calcareous spar to assume in some cases an equatorial, in others, an axial position. It is, however, probable that here secondary causes come into play, which are not yet fully understood.

(4) Pogg. Ann. LXXVIII, 427.

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## I. Negative uni-axial Crystals.

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|-------------------|-----------------|
| 1. Magnetic.      | 2. Diamagnetic. |
| Tourmaline.       | Antimony.       |
| Beryl             | Calc-spar.      |
| Diopase.          |                 |
| Arsenide of Lead. |                 |
| Vesuvian.         |                 |

## II. Positive uni-axial Crystals.

- |                  |                    |
|------------------|--------------------|
| 1. Magnetic.     | 2. Diamagnetic.    |
| Arsenic.         | Bismuth.           |
| Green Vitriol.   | Quartz (slightly). |
| Binoxide of Tin. |                    |
| Scapolite.       |                    |
| Troostite.       |                    |

## I. Negative bi-axial Crystals.

- |                           |                  |
|---------------------------|------------------|
| 1. Magnetic.              | 2. Diamagnetic.  |
| Red Prussiate of Potassa. | Antimony-glance. |
| Staurolite.               | Arragonite.      |
| Mica.                     | Nitre.           |
| Diopside.                 |                  |
| Tungsten                  |                  |

## II. Positive bi-axial Crystals.

- |              |                 |
|--------------|-----------------|
| 1. Magnetic. | 2. Diamagnetic  |
| Cyanite.     | Copper-glance.  |
| Augite.      | Bournonite.     |
| Hornblende.  | Glauber's Salt. |
| Actynolite.  | Gypsum.         |
|              | Topaz.          |

Augite and the uni-axial *magnetic binoxide of tin* manifested magnetic polarity in a definite direction like *cyanite*. The crystals of specular iron from Elba exhibited a very peculiar behaviour. They remained in a state of quiescence in any position in which they were held for a moment, whatever was the relation of their longitudinal dimension towards the line of the poles. Plücker supposes that this phenomenon is dependent on a certain degree of magnetic coercive power, and if this degree could be met with in a particle of steel, it would comport itself exactly like the crystals of specular iron.

Plücker's law relative to the direction of the optic axis in the magnetic field, has derived a higher interest and greater certainty from the ingenious elucidation which it has received from Wiedemann. His explanation is based on the following results obtained by himself(1), viz., that plates of crystals exhibit an unequal conducting power for electricity in different directions, precisely analogous to what Sénarmont has found respecting the propagation of heat, and to what has been long known respecting the propagation of light.—A comparison of this deportment with the optical properties gives the remarkable result, that crystals which in the same time transmit electricity more rapidly in the direction of the principal axis, than in any other direction, belong to the optically-negative, and that all the rest, with the exception of felspar (?), belong to the optically-positive crystals; so that if the few crystals examined justify us in deducing this conclusion, the electric fluid is most rapidly conducted through crystals in the same direction, in which light is propagated with the greatest celerity. Wiedemann(2) now concludes that if in crystals molecular

(1) Pogg. Ann. LXVI, 404 ; Comp. this Report, 129.

(2) Pogg. Ann. LXXVII, 534.

currents could be induced through the magnetic poles, it might be fairly assumed that the crystal, if permitted to move freely in the magnetic field, would always take such a position as would place the plane of the easiest transit for the molecular currents perpendicularly to the magnetic axis, *i. e.*, equatorially, when the molecular currents in the crystal and in the magnet would be parallel to each other.

The crystals of bismuth, as is well known, until recently, have been attributed to the tesseral system. But not only has G. Rose(1) proved that artificial crystals of bismuth affect the form of a rhombohedron, very slightly differing from the cube,—only somewhat elongated in the direction of the principal axis (the angle of the terminal edge being  $87^{\circ} 40'$ ),—but Faraday(2), also in consequence of the irregular phenomena presented in the magnetic field by cylinders of bismuth cast in a glass tube, has remarked that the magnetic behaviour of the crystals of bismuth supports the recent determination in crystallography. The crystallographic principal axis, or in other words, the line which is perpendicular to the plane of the most perfect cleavage, always manifested a tendency towards an axial position, surmounting even the ordinary diamagnetic force. The crystal, or even a group of similarly directed crystals, assumed this position with the greatest intensity when the principal axis of crystallisation of the crystal, or as it is named by Faraday, “the magne-crystallic axis,” could freely oscillate in a horizontal position. On the contrary, if the axis coincided with the prolongation of the thread of suspension, the directing force or the magne-crystallic force of the crystal was in abeyance, and the diamagnetic phenomena re-appeared unobstructed by any interfering influence. The crystals were, moreover, under all circumstances, repelled from each single pole, precisely like a mass of uncrystallised matter. The magne-crystallic force totally disappears in an irregular mass of small bismuth crystals, or in a tube filled with bismuth powder. In the same manner Faraday succeeded in neutralising this force by combining in a right angle three minute plates of bismuth split in the direction of the easiest cleavage.

If a spherical or cubical form is given to a crystal of bismuth, in order to exclude the disturbing influence of diamagnetism, the magne-crystallic force communicates to this piece of bismuth the character of a delicate needle which everywhere in the magnetic field, even of a weak horse-shoe magnet, assumes a direction parallel or tangential to the magnetic curve or line of magnetic force passing through the place, and consequently may be employed for detecting this direction. Every small piece of soft iron, of wire, every small magnet which is brought

(1) Comp. this Report, 9.

(2) Phil. Trans. 1849; Arch. Ph. Nat. X, 225; XII, 89; Instit. 1849, 52 (in abstr.) Pogg. Ann. LXXXVI, 144; Phil. Mag. [3] XXXIV, 75; Ann. Ch. Pharm. LXXXII, 185—189.



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into proximity, alters the position of the magne-crystallic axis of the piece of bismuth, in accordance with the direction of the line of magnetic force.

Faraday found that the magne-crystallic directive power was retained under the influence of an electric spiral, exactly as in the field of an electro-magnet, or tolerably weak horse-shoe magnet; the principal axis of crystallisation assuming always a direction parallel to the axis of the spiral.

In order to test the influence of the surrounding matter on the magne-crystalline directing force of bismuth, Faraday fixed the magnetic poles about two inches asunder, and suspended a crystal of bismuth in the middle of the magnetic field and observed its vibrations and set. He next introduced blocks of bismuth, about 2 square inches in the base and three-fourths of an inch in thickness, between the poles and the crystal, without being able to detect the least perceptible influence on the latter. When the crystal was suspended between the poles of the horse-shoe magnet immersed in water, it assumed the same position as in the air, and precisely the same number of revolutions of the thread of suspension were required to turn the crystal from the axial to the diametrical position, as were necessary to produce the same change when it was surrounded by air only.—The crystal showed exactly the same deportment when immersed in a solution of green vitriol.

From his experiments with bismuth plates, Plücker(1) believes that he is justified in assuming, in addition to the principal magne-crystallic axis, a second similar axis which is perpendicular to a second less perfect plane of cleavage. The plates exhibited three systems of parallel stripes, which intersected each other at angles of  $120^\circ$ . One of these systems was specially prevalent, and manifested a strong tendency to assume the equatorial position in the magnetic field, whenever the principal axis was in a direction vertical to the length of the suspending thread.

Antimony which also crystallises in the hexagonal system, and the terminal angle of which, according to Rose,  $= 87^\circ \cdot 35'$ , likewise exhibits a magne-crystallic deportment. Faraday finds that the axis of antimony crystals, which is perpendicular to the easiest plane of cleavage, assumes as in bismuth an axial position. According to Plücker(2), who confirms the accuracy of all Faraday's experiments, which have been mentioned above, its direction is equatorial.

Faraday observed, moreover, in antimony, several additional phenomena which he describes in the following manner. When the magne-crystallic axis was horizontal, and a certain crystal was used, upon the evolution of the magnetic force, the crystal took up its position

(1) Pogg. Ann. LXXVI, 576; Ann. Ch. Pharm. LXXII, 190.

(2) Ibid.

more slowly, and pointed as with a dead set. If the crystal were moved from this position on either side, it returned to it at once; there was no vibration. Other crystals did the same imperfectly, and others again made one or perhaps two vibrations, but all appeared as if they were moving in a dense fluid, and were in that respect utterly unlike bismuth in the freedom and mobility with which it vibrated. If the magne-crystallic axis was vertical, so that the directing force could not be exerted, the crystal suddenly stopped when the magnetic force was excited, and if its greatest length was out of the axial or equatorial position, a retrograde motion ensued on the discontinuance of the electric current. This was especially manifest when the longitudinal axis of the crystal formed an angle of  $45^\circ$  with the axis of the magnetic field.—Faraday conjectures the cause of these phenomena to be induced currents, which are excited in antimony precisely as in copper and other metals, when they are under the influence of magnetism. Since these currents can only be produced in a continuous mass of certain dimensions, groups of incoherent crystals, and very thin split plates, when suspended horizontally, scarcely exhibited any of the above-mentioned phenomena. Weak horse-shoe magnets can scarcely excite a trace of such a current, and on this account they are specially adapted to the investigation of the magne-crystallic phenomena in antimony. Faraday(1) discovered, moreover, magne-crystallic directing force in arsenic, iridium, osmium, titanium, tellurium, green vitriol, and in sulphate of nickel. On the other hand, zinc, copper, tin, lead, gold, diamond, rock-salt, fluor-spar, borax, suboxide of copper, binoxide of tin, cinnabar and galena, exhibited no traces of this force.

As the magne-crystallic axis in green vitriol is perpendicular to the prismatic axis, these crystals exhibited at first sight a very striking behaviour. When such a prism at first assumes an oblique position in the magnetic field, it apparently withdraws from the magnetic poles on closing the circuit. In this instance the magne-crystallic force predominated over the magnetic force of the mass. A crystal of bismuth, whose magnetic axis coincides with its longitudinal dimension, affords under similar conditions a contrary anomaly. It appears in opposition to its diamagnetic property to approach the poles.

Faraday(2) had conjectured that the magnetic force which directs the crystal, when formed, would also so dispose the molecules constituting the crystal that the principal axis of the rhombohedron would be in the axial position. Plücker(3) and Wiedemann(4) have the merit

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(1) Pogg. Ann. LXXVI, 146.

(2) Phil. Trans 1849, I; Arch. Ph. Nat. XII, 109.

(3) Pogg. Ann. LXXVI, 582.

(4) Pogg. Ann. LXXVII, 536.

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of confirming this view by experimental evidence. Plücker cooled fused bismuth in a porcelain dish, or in an excavated piece of charcoal, between the two half armatures of an electro-magnet, and drew on the mass when solidified a line in the direction of the magnetic axis. When suspending it by a silk thread in the position in which it had solidified, the line drawn invariably assumed after a few oscillations the axial position.

E. Becquerel(1) has measured the intensity with which a magnetic pole operates on bodies of different masses, but of similar form, on the principle of the torsion-balance, *i. e.* by the torsion of the suspending thread. The intensities remained proportional to each other when the force of the current varied. His remarks respecting the influence of the surrounding matter, and of the magnetic force of gases, as yet present no new feature, and we must reserve a more detailed account and a decided opinion on these researches until their entire publication. For the present we direct our readers' attention to one single point. Becquerel advances the position, *that every body is attracted by the magnetic pole* with a force equal to the difference of the forces acting upon such body, and on the surrounding medium. Now, as bismuth, sulphur, phosphorus, &c., retain a tendency to assume an equatorial direction even *in vacuo*, Becquerel, in order to avoid the assumption of diamagnetism, is compelled to adopt the hypothesis, that the imponderable ether which fills the vacuum, is more powerfully attracted by the magnetic pole than the substances above-mentioned.

Plücker(2), on the contrary, retaining the two antagonistic actions of magnetism and diamagnetism, has shown that all the phenomena which very dissimilar bodies present in different media under the influence of a magnetic pole, are capable of an easy explanation on an extension of the Archimedean principle.—Suppose a body immersed in a fluid in the vicinity of which there is a magnetic pole, the action of the latter may be expressed thus: the attraction of any magnetic body which is immersed in a magnetic or in a diamagnetic fluid, decreases or increases exactly in the proportion to the amount of the magnetic attraction or diamagnetic repulsion of the fluid displaced by the introduction of the immersed body. On the contrary, the repulsion of a diamagnetic body immersed in the same fluid, increases or decreases precisely as much as the magnetic attraction or diamagnetic repulsion of the fluid displaced by the body so introduced.

Consequently, if the immersed body as well as the fluid be both

(1) Compt. Rend. XXVIII, 623; Arch. Ph. Nat. XI, 212; Instit. 1849, 161; Ann. Ch. Pharm. LXXII, 197 (in abstr.); more in detail (1850) Ann. Ch. Phys. [3] XXVIII, 283.

(2) Pogg. Ann. LXXVII, 578; Ann. Ch. Pharm. LXXII, 199 (in abstr.).

magnetic or diamagnetic, but if the fluid be the stronger of the two, the magnetic body will be repelled, the diamagnetic attracted.

A magnetic fluid becomes apparently heavier when a magnet is in operation under it; a diamagnetic, on the contrary, becomes lighter. When the magnet operates above the fluid, the effects are just the reverse. If a glass bulb furnished with a narrow areometer-tube, and filled with mercury, be immersed in a solution of sesquichloride of iron or of green vitriol, the apparatus will rise or fall accordingly as a magnetic pole is placed under or over the apparatus. This phenomenon is caused by the alteration of the gravity of the fluid, for the apparatus itself is only very slightly affected by the magnet. If the areometer-bulb and the fluid be placed between the two magnetic poles, the former will be propelled from the centre towards the nearer pole when the fluid is magnetic, on the contrary, it will be retained in the centre when the fluid is diamagnetic.

In this place Plücker communicates some measurements which are intended to show the influence of the surrounding medium, and to prove afresh the unequal decrease of the magnetic and diamagnetic force when the strength of the current is diminished. A bismuth globe of from 10 to 12 millimeters in diameter suffered the following repulsions expressed in milligrammes :

	8 Cells.	4 Cel
In the Air	785	—
In Water	745	490
In a solution of Sesquichloride of iron	885	1050

F. Reich(1) announces that he has confirmed by experiments, made on a larger scale, the fact already mentioned in our last Report, (vol. i. 200) viz., that on simultaneously bringing the north and the south pole of a magnet near a globe of bismuth, the difference only of the action of the two poles is perceptible.

W. Thomson(2) propounds certain propositions in reference to the equilibrium of magnetic and diamagnetic bodies of any form under the influence of terrestrial magnetism. We cannot enter into details respecting these propositions, as the principles on which they are founded have not yet been communicated.

Ward(3) has published some observations on the motion of metals under the influence of magnetic forces, together with his own views on the theory of induced electric currents, which are to be assumed for the purpose of explaining diamagnetic phenomena.

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(1) J. Pr. Chem. XLIX, 193.

(2) Report of the Br. Ass. for 1848; Not. and Abstr. 8; Instit. 1849, 63.

(3) Instit. 1849, 406.

Electri-  
city.  
Its theory.

**Electricity. Its Theory.**—Maas, of Namur(1) has undertaken a critical analysis of the prevailing views regarding electricity. He attempts to demonstrate that the theory of two electric fluids, upon which the explanations of electrical phenomena is usually based, is unnatural and but imperfectly applicable to the phenomena. The latter portion of his arguments has not proved very successful, as Maas will himself perceive, if he enters more deeply into the study of electricity, and especially if he makes himself acquainted with the labours of P. Riess on statical electricity. We may postpone the consideration of the first part until that period.

**Electrometry.**—Every electric body constantly loses electricity by diffusion in the atmosphere. The constitution of the atmosphere remaining the same, this loss amounts in the same space of time, as Coulomb was the first to show, to an unalterable fraction of the amount of electricity present in each moment of time; or, in other words, the loss of electricity in the time-unit is proportionate to the density of the electricity.

In a treatise quoted in our last Annual Report (Vol. I, 206), Riess has demonstrated that apparent deviations from this law, which may occur in experiments with the torsion-balance, are mainly attributable to the inductive effect of the electric testing globe, and the ball of the beam exerted upon the glass walls of the torsion-balance, whereby the loss of electricity is apparently or really diminished; the consequence of which is, that it is found less, and particularly so when the charge is powerful, than the law of Coulomb demands. Riess, therefore, recommends torsion-balances of rather considerable dimensions, so that the ball of the beam may be at least  $1\frac{1}{2}$  inches removed from the glass case. He also, for the same reason, advises that the ball be charged uniformly, and not too powerfully(2).

Matteucci, who does not appear to have been acquainted with this important investigation (though it was published as early as 1847), was led to conclude from experiments instituted with the torsion-balance, that the loss of electricity experienced by bodies is not proportional to the density of electricity either in a dry(3) or in a damp(4) atmosphere; and that the law given by Coulomb is only applicable to air of a mean hygrometric condition. He states the loss to be constant within certain limits in dry air, and to be proportional to time, only *i. e.* that in equal periods it was uniform whatever the electrical tension may be. Consequently, when viewed as a fraction of the amount of electricity present, the denominator of the fraction

(1) Instit. 1849, 132.

(2) Pogg. Ann. LXXI, 369.

(3) Ann. Ch. Phys. [3] XXVIII, 385; Compt. Rend. XXVIII, 508; Instit. 1849, 154; Arch. Ph. Nat. XI, 43.

(4) Ann. Ch. Phys. [3] XXVIII, 421; Compt. Rend. XXIX, 305; Arch. Ph. Nat. XII, 232.

would decrease, *i. e.* the loss would increase, the more electricity had been given off.

Matteucci(1) has also published a treatise on the diffusion of electricity in solid non-conductors, which is tolerably extensive but very imperfect, and therefore only of trifling interest. Matteucci appears to be entirely ignorant of what other physicists have done before him.—He gives a detailed description of the torsion-balance which he employs. It has the advantage of an access from below, which may be closed.

**Conducting Power of Crystals in different Directions.**—Some physicists have supposed that in certain crystalline bodies which are bad conductors, a varying power of conduction was perceived in different directions. In order to determine the dependence of the power of conduction upon the direction, supposing it has any existence, Wiedemann(2) has employed the following ingenious method. If a glass or resinous surface be strewed with a fine, non-conducting powder, such as lycopodium, minium, and the like, and an insulated fine point, such as a needle, be fixed, with a suitable holder, perpendicularly to the surface—if then the ball of a Leyden jar charged with positive electricity be brought near to the needle, the powder is uniformly dispersed round the electrified point in all directions, in consequence of the uniform electric repulsion. An almost circular figure traversed by rays is formed by the denuded surface, which much resembles the well-known figures of Lichtenberg, obtained by strewing some powder on a resinous plate charged with positive electricity at one point. The phenomenon is only produced by positive electricity. When negative electricity is employed, the figures produced have very indistinct margins. If instead of glass the surface of a crystal is used, such as a lamina of gypsum, it is seen that the powder is no longer removed from the electrical point uniformly in all directions, but chiefly in two opposite directions, and least in the line perpendicular to the former. The surface of the gypsum thus exposed, approaches to an ellipse, the major axis of which forms a right angle with the principal axis of the crystal. The conducting power of crystallised gypsum is therefore lowest in the direction of its crystallographic principal axis, and attains its maximum value perpendicularly to this direction. A similar deportment is exhibited by heavy spar, celestine and some other crystals, which belong to the optically-positive crystals in reference to the unusually refracted ray, whilst in others, such as calcareous spar, arragonite, tourmaline, apatite, which belong to the optically-negative crystals, the longitu-

(1) Ann. Ch. Phys. [3] XXVII, 133.

(2) Pogg. Ann. LXXVI, 404; Arch. Ph. Nat. XII, 46; Ann. Ch. Phys. [3] XXIX, 229.

Conduct-  
ing power  
of crystals  
in different  
directions.

dinal direction of the electrical figure, or, which is the same thing, the direction of the greatest conductivity is parallel to the principal axis. Alum, fluor-spar, and other crystals of the Regular system, exhibited the same deportment as glass, *i. e.*, the figure formed on the surface was circular.

If, as these experiments prove, the electricity in the mass of a crystalline body exhibits an unequal conductivity in different directions, it is to be expected that the planes of the molecular currents induced in the crystals by a magnet must be chiefly parallel to the longitudinal direction of the above-mentioned electric figures; that therefore a crystal suspended freely between the poles of a magnet must always assume a position in which the longitudinal direction, *i. e.* the direction of the smallest resistance to conduction, obtains an equatorial position. These conclusions were entirely confirmed by experiments made by Wiedemann(1) himself, and by some instituted at the same time by Plücker(2); both these inquirers have found that the optic axis is attracted in optically-positive, and repelled in optically-negative crystals. This contrast, which was first made known, though not explained, by Plücker, consequently depends upon the fact that electricity is in one class of crystals best conducted in the direction perpendicular to the principal axis, in the other parallel to the axis.

The former of the two treatises of Wiedemann, which we have mentioned, appeared in the March number of Poggendorff's *Annalen* for 1849. On the 17th of December, or 8 months later, Sénarmont(3) presented to the Academy of Sciences of Paris a series of similar experiments, which were conducted in the same manner(4), and led to the same results, without making the slightest mention of the earlier and more complete investigation. We may assume that it was unknown to him, though it does not follow that it takes as long to make the Parisian academicians acquainted with the contents of Poggendorff's *Annales*(5).

**Atmospheric Electricity.**—In a treatise *sur le climat de la Belgique*, Quetelet publishes a series of very remarkable observations

(1) Pogg. Ann. LXXVII, 534.

(2) See p. 121 of this Report.

(3) Compt. Rend. XXIX, 750.

(4) He cemented a tin lamella on the face of the crystal, in which an exact circular opening was made. He then, by means of a fine point, conducted the electricity of a jar, or of the conductor of the machine, into the middle of the free space. If the experiment was made in the dark, and in an attenuated atmosphere, a luminous circle became visible during the discharge when homogeneous substances and crystals of the Regular system were employed; in other crystals a more or less distinctly marked line of light was seen from the position of which Sénarmont judged of the direction of the easiest transit.

(5) Sénarmont's treatise has since been reprinted in the *Ann. Ch. Phys.* [3] XXVIII, 257 (March number, 1850), and here for the first time Wiedemann's earlier memoir has been noticed.

on atmospheric electricity(1). According to these, if we proceed from a place which is nowhere commanded by higher points in the vicinity, the intensity of atmospheric electricity bears a direct ratio to the height of the layer of air below, and augments so rapidly with the increase of height, that as Peltier(2) has formerly found, differences of elevation of a few feet produce important differences of intensity. This deportment is at present, however, established only for very narrow limits of observation.

Moreover, Quetelet has concluded from the mean of observations made during from 4 to 5 years, that in Brussels the atmospheric electricity attains its maximum of intensity in January, gradually diminishes until June (the period of its lowest point), and then again gradually increases until the end of the year. The months of March and November correspond to the mean amount of electricity of the year. Excepting the months of June and July, in which the amount of electricity was nearly uniform in all weathers, it was greater in fine weather than when the sky was clouded, and this difference increased up to January. The mean accumulation of atmospheric electricity at the period of the maximum was 13 times that of the minimum. But if the fine days alone are compared, the difference between a fine day in January and a fine day in June is on an average still greater.—The daily variations showed, as has been found elsewhere, two daily maxima and minima; the former in the morning and evening, the latter in the afternoon and in the night. Negative electricity was very rarely found on (a few) dull days.

Quetelet recommends the gold-leaf-electroscope, employed and described by Peltier in his treatise, for the purpose of studying the electric constitution of the atmosphere; he also uses the electrometer of the latter, in which the needle moves horizontally. Quetelet finds that the galvanometer, with a long multiplying-wire, is but slightly sensible to atmospheric electricity.

Birt(3) has only found negative electricity in 665 out of 15170 observations on atmospheric electricity which were made at the observatory in Kew during 5 years. He concludes from the observations of 3 years that the electric tension of the atmosphere is at its minimum at 2 A.M., that it increases slowly up to 6, much more rapidly (about doubly) until 8, and then again less rapidly until 10 A.M., this being the maximum point for the morning. Gradual diminution then takes place until 4 P.M., at which time, however, the tension continues higher than at 8 A.M. This is the second minimum. A rapid increase now follows up to 8 P.M.; and there is a second

(1) Arch. Ph. Nat. XI, 177 (in abstr.).

(2) Recherches sur la cause des phénomènes électriques de l'atmosphère et sur les moyens d'en recueillir la manifestation. Paris, 1842.

(3) Instit. 1849, 311; Arch. Ph. Nat. XII, 224.



Effects of  
lightning.

maximum at 10 P.M., which exceeds that of 10 A.M. A rapid decrease follows up to midnight, from which period to 2 A.M. the tension still diminishes a little.

**Effects of Lightning.**—Trees, especially oaks and beeches, are not unfrequently fissured and split by the effect of lightning. Ch. Martins(1) attempts to explain this phenomenon by a large mass of vapour, which is suddenly evolved by the electric discharge. He bases this assumption upon the statement that immediately after the lightning has struck a large body of vapour is generally noticed to rise from the tree itself, and that the splinters when examined immediately afterwards appear perfectly desiccated.

**Lateral Discharge of the Electric Battery.**—Hitherto it has been thought that lateral discharges of the electric battery could only occur when the direct discharge was imperfect. Riess(2), however, has now proved that this condition is by no means requisite for the production of a lateral discharge.

A complete conduction to the ground was secured by a firm union of the single parts of the closing wire, a part was stretched in a straight line, and at a certain point a piece of wire (the branch) fixed at right angles upon it. Another insulated wire was fixed in the continuation of the former, though separated from it by a layer of air. This lateral wire could be put in communication with an electrometer. If the branch and the lateral wire were brought into contact as conductors, the vibration of the gold leaf of the electrometer exhibited a transient tension as often as the battery was discharged. If both wires, viz., the branch and the lateral wire, were separated by the balls of a spark-micrometer, a spark appeared between both balls, as often as a sufficient amount of electricity was discharged by the closing conductor. The electrometer was afterwards seen to maintain the same electricity as that with which the inner coating of the battery was charged. The divergence of the gold leaves thus produced was not, however, in a definite relation to the charge of the battery, because the electricity that had passed to the lateral wire, if sufficiently intense, for the most part again crosses over to the branch, after the battery has been discharged, in other words, a double spark occurs between the two balls of the spark-micrometer when the discharges are powerful, and when the balls are only separated by a small distance.

Riess has deduced the following law from the greatest interval of the two balls at which the lateral spark still occurred for a given charge of the battery: *the striking distance of the lateral discharge is proportional to the square of the density of the electricity accumulated*

(1) Instit. 1849, 5; Arch. Ph. Nat. X, 44.

(2) Berl. Acad. Ber. 1849, 46; Pogg. Ann. LXXVI, 466; Instit. 1849, 230; Arch. Ph. Nat. XI, 304.

*in the battery*(1). The shorter the closing wire placed between the point of transition of the lateral discharge and the interior of the battery, the greater the striking distance appears, the density of the charge remaining the same. The elongation of the lateral wire also presented some, though only a limited, influence upon the phenomenon. If the conducting resistance of the closing conductor was increased, which is well known to diminish the force of the discharging current, the lateral discharge, on the contrary, was strengthened. From these facts it appears that the lateral discharge is an effect produced by the excess of the electricity of the internal coating over that of the external coating of the battery. During the discharge the surface of the closing conductor is by this excess for a moment charged with free electricity, and is thus enabled to exert an inductive influence upon its neighbourhood.

Lateral  
discharge  
of the  
electric  
battery.

From this deportment an interesting result occurs when a battery is discharged by a branched closing wire. If one branch is interrupted by a layer of air, the discharge should, according to the ordinary laws, take place only by the other. But if the charge is sufficiently powerful this will not be the case, for a spark will appear at the point of interruption, and the discharge then takes place by both branches. This spark belongs to the lateral discharge, and the partial discharge of the main current by the interrupted branch occurs in consequence of the transit having commenced. From the moment of the appearance of the spark a change has occurred in the condition of the air, it has become attenuated, and is filled with particles torn from the balls(2).

Dove concludes from his experiments on discharge *par cascade*(3), that the period of discharge is inversely proportional to the number of jars that are connected in gradation. He found that the striking distance in the passage of electricity from one jar to another is proportional to the square of the number of jars. Riess has now given an explanation of the intimate connection of these experimental positions, and has proved the correctness(4) of Dove's deduction. Proceeding upon the law which is probable in itself as well as confirmed by all our recent experiments, that the velocity of electric motion is proportional to its density, the law discovered by Riess for the striking distance of a quantity of electricity in motion may be thus expressed: the striking distance is in the ratio of the square of the velocity.—If, therefore, the velocity of the discharge *par cascade* increases proportionately with the number of

(1) Compare "Schlagweite ruhender Electricität," in Pogg. Ann. XL, 321; LIII, 1; LXXIII, 379.

(2) Pogg. Ann. LIII, 14; also Ann. of Electr. III, 507; Annual Report for 1847 and 1848, Vol. I, 206.

(3) Annual Report for 1847 and 1848, Vol. I, 210.

(4) Pogg. Ann. LXXVI, 482.

Phenomena occurring during the discharge of the Leyden jars.

jars, the striking distance necessarily is such as was observed by Dove.

**Phenomena occurring during the Discharge of the Leyden Jars.**

—In a treatise on the mechanism of the electric discharge, Riess has demonstrated the process of the discharge, which has chiefly been elucidated by his own researches; he, however, adds no new facts(1).

Knochenhauer has in the past year published the following treatises, which are not adapted for analysis :

On the changes which the discharging current of an electric battery suffers when the closing wire is brought into connection with a second battery(2).

On the resistance of the air at the closing conductor of the battery(3).

On the lateral discharges at the closing conductor of the battery(4).

**Electroscopic Department of the Galvanic Pile.**—Ohm's law of the electric current, as is well known, is based upon the view that the electro-motive force, or the moving force of the electric current, is essentially an electric tension caused by a definite and permanent difference in the density of the free electricities developed at the points of contact of two heterogeneous bodies. It is found that the electric density when one end of the open electric pile is in contact with the earth, if we commence at this end, increases in a direct ratio with the number of the pairs. Now, the electric difference which thus results is to be maintained in the closed pile, but to be distributed throughout its entire length, so that in every transverse section, with reference to its reduced conducting resistance, the exact electric tension is present, which is required to set in motion equal quantities of electricity in all transverse sections at the same time. Consequently, if the resistance between two transverse sections taken at random, as well as the entire conducting resistance of the closed pile be known, the electric difference appertaining to the entire pile may be calculated from the difference of density within the limits of the selected portion. The force of the current is proportional to this difference as long as the conducting resistance remains unchanged. Generally, therefore, the force of the current must bear the relation of the electric *fall*, if we may use this expression, *i. e.* of the electric difference for the length-unit of the reduced resistance. But this is nothing else than the entire electric difference divided by the entire conducting resistance.

Ohm has himself demonstrated the actual presence of free electricity in a state of tension in the closed circuit of the pile; but the law of distribution, as required by theory, was hitherto rather presumed as a necessary consequence than proved by accurate experi-

(1) Pogg. Ann. LXXVIII, 433.

(3) Pogg. Ann. LXXVIII, 42.

(2) Wien. Acad. Ber. 4. Heft, 10.

(4) Pogg. Ann. LXXVIII, 54.

ments. Kohlrausch(1) has lately discovered real inequalities in the electric densities at different points of the closing conductor of the pile, by the aid of the electrometer of Dellmann, as improved by himself, and of the condenser(2). If the closing conductor consisted of a long thin wire, of uniform thickness throughout, the difference observed between two points increased in a direct ratio to the length of the wire lying between the two points. If the closing conductor was formed by two wires of unequal diameter, the electric differences for equal lengths of the wires bore a relation inversely as the transverse sections. If one wire was copper, the other German silver, the electric differences were found for equal lengths and thicknesses to be directly as the resistances to conduction.

In liquid conductors it was found that, the transverse section of the liquid being equal, the free electricity increased proportionately to their length.

Kohlrausch found, in accordance with former though less accurate measurements, the electric difference of an open copper-zinc-pile to be composed of the electric actions of the two metals upon one another and upon the liquids. On connecting the two poles of this pile by a long and thin wire, and testing the separate portions of the pile that had been thus closed, the sum of the electric differences of all the divisions proved to be but little less than the electric difference of the open pair. Kohlrausch concludes from this, that the assumption of Buff(3), that the electric difference between copper and zinc is the only moving force acting in Daniell's battery, must be incorrect. This assumption has not, however, been expressed in so general a manner; it is only stated that the electromotive force, which in weak currents is undoubtedly present at the point of contact of solid and liquid conductors, becomes either entirely or almost entirely inoperative in the case of strong currents, an assumption which is by no means in contradiction with the observations communicated by Kohlrausch, and is also irresistibly proved by a series of well-accordant experiments.

Ohm assumed the electricity in a state of tension to be of the same density at every point of the same transverse section of uniform thickness in the closed pile. This assumption, however, which is contradicted by electrostatics is, as Kirchhoff(4) has proved, unnecessary. For proceeding from the assumption which agrees with the electrostatic phenomena, that electricity in a state of tension can only exist at the surface of a conductor, he arrived at the same analytical expression for the amount of moving electricity as that resulting from Ohm's view.

(1) Pogg. Ann. LXXVIII, 1.

(2) Annual Report for 1847 and 1848, I, 206.

(3) Pogg. Ann. LXXIII, 507; Annual Report for 1847 and 1848, Vol. I, 226.

(4) Pogg. Ann. LXXVI, 506.

Electro-  
chemical  
theory.

**Electro-chemical Theory.**—Becquerel, senior(1) has communicated some general reflections on the electro-chemical theory, which are not, however, adapted for analysis; we must, therefore, content ourselves with referring the supporters of this theory to the original. They are, however, not likely to meet with much that is new to them.

Schönbein(2) also has published a treatise on this subject; at the close of which he expresses himself to the effect, that we cannot seriously think of establishing a theory of the kind at present. We are of the same opinion as far as regards Schönbein's theory, and therefore consider it superfluous to enter into its contents more fully at present.

**Voltaic Pile.**—Foucault(3) describes an altered disposition of Bunsen's pile, the object of which is to facilitate its arrangement when several pairs are to be united to form a single one. This disposition consists mainly in this, that the porous cells, together with the attached zinc plates, may be simultaneously immersed into, and removed from the nitric acid vessels in which the carbon-cylinders remain until the nitric acid is exhausted. These porous cells are at the same time united by glass syphons which are permanently filled, and by which it is possible to renew the liquid during the experiment.

In cases in which it is desirable to obtain currents of slight intensity but of long duration, Eisenlohr(4) recommends the following three bi-cellular combinations. In the first the copper is immersed in a dilute solution of sulphate of copper, and the zinc in a solution of bitartrate of potassa, to which an excess of the salt has been added. In the second the sulphate of copper is replaced by dilute sulphuric acid; in the third moreover the copper-plate by pieces of coke. The first of these piles is said to maintain a uniform current only when it is permanently closed, whilst the other two, and especially the second, maintained their uniform action for six weeks, even when alternately opened and closed. The last two are especially adapted for telegraphic purposes.

A few experiments with Voltaic pairs, instituted by Adie(5), chiefly with the view of studying the effect of the amalgamation of zinc have not thrown any new light on this question.

**Gas-Battery.**—Beetz has continued(6) his researches on the gas-battery(7). He formed gas-chains with platinised strips of platinum,

(1) Ann. Ch. Phys. [3] XXVII, 5; J. Pr. Chem. XLVIII, 193; Compt. Rend. XXVIII, 658 (in abstr.).

(2) Pogg. Ann. LXXVIII, 289; Arch. Ph. Nat. XIII, 192.

(3) Inst. 1849, 163.

(4) Pogg. Ann. LXXVIII, 65.

(5) Chem. Soc. Qu. J. II, 97.

(6) Pogg. Ann. LXXVII, 493; Phil. Mag. [3] XXXVI, 81; Arch. Ph. Nat. XII, 285.

(7) See Annual Report for 1847 and 1848, I, 217.

having as nearly as possible the same electrical properties, which were alternately charged with different gases and vapours; he determined the electro-motive force in every case, according to the method of compensation(1). As this method does not require the formation of an electric current, which is even avoided to the utmost, it affords a safe and perhaps the only means of measuring in their original condition forces of so inconstant a character as those operating in the gas-battery.

Gas-  
battery.

It is evident from these measurements that the electro-motive forces of gaseous bodies which are opposed to one another by the intervention of platinised platinum plates in dilute sulphuric acid, follow the law of the Voltaic tension-series in reference to one another, like those of the metals; in other words, the sum of the electro-motive forces of a series of gases, united two and two according to a definite order in a gas-battery, is equal to the electro-motive force of the two terminal members of this series. For instance, the effect resulting from hydrogen and pure platinum, increased by that resulting from pure platinum and oxygen, is equal to that produced by hydrogen and oxygen. As an electro-motive action of a definite magnitude was found to exist also between oxygen and pure platinum, the assertion of Schönbein that oxygen in the gas-battery only exerts a secondary influence(2) now appears to be confuted by numerical demonstration.

Beetz has also composed gas-batteries, in which strips of charcoal or pure plates of silver were substituted for the platinum. Although the electro-motive forces were then represented by other, and, as might expected, much smaller numbers, the relation of these numbers still continued the same as with platinum.

Assuming the force of the platinum-zinc-pile at 39·79, Beetz found that the forces of various platinum-gas-batteries are expressed by the following numerical values, the platinum coated with hydrogen being taken as point of departure :

Chlorine . . . . .	31·49	Platinum . . . . .	20·13
Bromine . . . . .	27·97	Bisulphide of carbon . . . . .	19·60
Oxygen . . . . .	23·98	Olefiant gas . . . . .	18·36
Protoxide of nitrogen . . . . .	21·33	Phosphorus . . . . .	16·06
Cyanogen . . . . .	21·16	Carbonic oxide . . . . .	13·02
Carbonic acid . . . . .	20·97	Sulphuretted hydrogen . . . . .	3·05
Binoxide of nitrogen . . . . .	20·52	Hydrogen . . . . .	0
Air . . . . .	20·50		+

The difference of every two of these numbers is the electro-motive force of the respective gaseous substances when opposed to each other in the platinum-gas-battery.

(1) Annual Report for 1847 and 1848, I, 216.

(2) Ibid.

Gas-  
battery.

The gas-battery differs essentially from the pile formed by polarised plates (as pointed out by Poggendorff soon after the invention of the gas-battery) in duration only. It may be compared to a secondary battery, the plates of which are very slightly polarised. In the same way as the electro-motive force increases in this instance by higher polarisation, the gas-battery exhibits the greater electro-motive action, the more completely the immersed plates become coated with the gas. On account of its great power of absorption, platinised platinum is peculiarly adapted to produce considerable electro-motive forces when employed in the gas-battery. All metals which become electro-negative when in contact with zinc, as well as zinc itself, as regards their electro-motive forces, are approximated as it were to the positive end of the tension-series when polarised with hydrogen. It has been concluded from this that zinc is electro-negative when opposed to hydrogen. Notwithstanding that, in the tension-series of gases which he gives, Beetz has assumed zinc as electro-positive(1) in reference to hydrogen. But the contradiction is only apparent, for the numerical value + (19.68) which is there given to the zinc, and by which it appears electro-positive in reference to hydrogen, merely designates the force which zinc excites when occupying the place of a gas in one glass tube of the gas-battery, the other being occupied by platinum coated with hydrogen (or as it were a mixture of hydrogen and platinum, in which the latter preponderates). Besides, the force thus determined can only be relatively compared to the electro-motive forces of the gas-battery; for under the same conditions which permit an increase of the latter, namely, an increasing thickness of the hydrogen coating of the platinum, its force diminishes. If the air be excluded, we may even succeed in entirely reversing(2) the polarity of platinum when opposed to zinc, by the influence of the hydrogen with which it is coated. We may therefore consider ourselves justified in assuming that pure hydrogen is electro-positive in relation to zinc, as required by the assumption of the tension-series.

As Beetz has found that the relation of the forces of the gas-batteries is independent of the absolute magnitude of these forces, one would expect to find the same relations prevailing in the electro-motive forces of plates polarised by gases, *i. e.*, coated with gases by electrolysis. Experience does not, however, bear out this expectation. We pointed out in the last Annual Report(3) that the deportment of platinum, according as oxygen or hydrogen are deposited upon it, appears to indicate that it may be polarised with about equal intensity by both gases. Beetz now derives a new proof of the correctness of this

(1) Pogg. Ann. LXXVII, 504.

(2) Ann. Ch. Pharm. XLI, 139.

(3) Annual Report for 1847 and 1848, I, 225.

deportment, from a comparison and critical investigation of several measurements made by various physicists as well as by himself(1).

**Passive State.**—According to Reuben Phillips(2), iron remains passive and lustrous in chromic acid of different degrees of dilution, and even attains a more passive state in it than in iodic or in nitric acid of 1.39 spec. grav. The iron also became passive in chloric acid and in binoxide of hydrogen.

**Force of Constant Batteries.**—Louyet, at Brussels, has instituted experiments on the decomposing force and on the degree of constancy of some batteries. The results which he communicates(3), possess, however, no scientific value, because in his experiments he operated under unequal conducting resistances which he did not measure, and to which, in fact, he did not pay the slightest attention. Thus, for instance, he found that 4 of Bunsen's elements yield 10 times the quantity of gas as 2 pairs; this is only possible if the impediments to conduction amounted in the latter case to much more than double of what they were in the former.

**New Method of determining this Force.**—For the purpose of determining the force of constant electric currents, Feilitzsch(4) recommends an apparatus resembling Weber's small magnetometer. A very short magnetic needle vibrates over the middle of a line which cuts the magnetic meridian at right angles, and is divided on both sides into millimeters; in order to render deflections from the zero-position more perceptible, the needle is provided with a long hand. At a suitable distance from it a coil of wire is placed upon the divided line in such a manner that the axis of its cylinder would, if prolonged, pass through the middle of the needle. As often as the current is conducted through the coil the needle is deflected. By the aid of a prismatic magnetic rod which is applied to it on the opposite side, it is restored to zero. With the assistance of a formula which Feilitzsch has developed for this purpose, an approximative value of the force of the current may be calculated from the distance between the middle of the rod and the middle of the needle, compared with the distance of the latter from the coil of wire; this value will prove the more accurate the greater the distance may be at which the rod and the coil continue to exert a perceptible influence upon the needle. This process certainly affords the possibility of obtaining accurate measurements even when an incorrectly graduated circle is employed. However, it is tedious, and the assistance of the magnetic rod is superfluous if the needle is accurately suspended over the middle of a well-graduated circle.

Passive  
state.

(1) Pogg. Ann. LXXVIII, 35.

(3) Instit. 1849, 253.

(4) Pogg. Ann. LXXVIII, 21.

(2) Phil. Mag. [3] XXXIII, 509.



New  
method of  
deter-  
mining  
this  
force.

As a minute magnetic needle cannot be dispensed with, a single large ring carried round the middle of the needle, or several circular coils lying close together, provided that their terminations were twisted so as to prevent their affecting the needle, would neither be more difficult to make nor more expensive than the contrivance selected by Feilitzsch. If, by means of a slide, the ring is also made to move at right angles to the quiescent position of the needle, and if its distance from the middle of the latter can be accurately measured, electric currents of widely different degrees of strength may be measured and compared with the greatest possible accuracy. The writer of these lines has advantageously employed a tangential needle with a moveable ring for several years. W. Weber has elucidated the theory of this instrument as early as the year 1842(1).

If the ring be composed of a larger number of coils of wire, the distances of which from the middle of the needle can no longer be regarded as equal, we cannot take the distance of the middle ring as representing that of the entire system of rings. A more accurate mean value of this distance may be obtained for this purpose by the aid of a formula, calculated by Hädenkamp(2).

**Current-Regulator.**—Jacobi(3) has indicated a new species of current-regulator, which he terms a mercurial voltagometer. This apparatus consists essentially of a wide glass tube filled with mercury, into which a thin platinum wire is immersed, and stretched to a straight line. The wire may be elevated and depressed by means of a screw, and the part that projects from the mercury may thus be lengthened or shortened. A scale placed near the wire serves to measure the part projecting. If an electric current enters at the upper end of the wire, and re-issues at the surface of the mercury, we obtain a means of introducing a variable length of resistance without interrupting the current. Jacobi asserts that the wire has not undergone amalgamation after remaining immersed in very pure mercury for several years. A few experiments are subjoined, which prove that very accurate and comparable measurements may be made with this apparatus which in this respect is a counterpart to Wheatstone's rheostat; it is a question, however, whether the possibility of introducing a longer wire in the latter does not give it a superior advantage. Jacobi considers Wheatstone's instrument less convenient to operate with, which we however do not find to be the case. If the precaution be taken to press the wire against the metallic cylinder of the regulator by a suitable contrivance, exactly at the spot where it is wound off, the casual trifling differences in the tension of the wire have no

(1) Pogg. Ann. LV, 27.

(2) Ibid. LXXVIII, 58.

(3) Petersb. Acad. Bull., VIII, 1; Pogg. Ann. LXXVIII, 173.

perceptible influence on the magnitude of the resistance. Moreover, the introduction and removal of the wire may be more rapidly effected by a crank and roller than by means of a screw. Conduct-  
ing  
resistance.

**Conducting Resistance.**—E. Becker, of Giessen, has ascertained the law, by which, in several liquids, the resistance to conduction decreases with an increase of temperature(1). The following equations by which he expresses the relations between temperature and resistance are the mean results of a very large number of experiments that agree very well, and therefore deserve great confidence. As they are intended only to mark the relation of the alterations that occur, and not their absolute magnitude, the resistance for  $t=0^\circ$  is uniformly assumed equal to 100.

Sulphuric acid of 1.24 sp.gr. purified, though containing traces of lead; between  $15^\circ$  and  $100^\circ$ :

$$r = 100 - 1.7120 t + 0.01122 t^2 - 0.00001840 t^3$$

Nitric acid of 1.36 sp. gr. ; between  $0^\circ$  and  $50^\circ$ :

$$r = 100 - 2.918 t + 0.06479 t^2 - 0.0005338 t^3$$

Sulphuric and nitric acids at the degrees of concentration mentioned, present the same resistance to conduction at  $20^\circ$ . If the temperature increases, that of sulphuric acid diminishes more rapidly than that of nitric acid.

Solution of sulphate of zinc containing 64.50 per cent of the crystallised salt; between  $9^\circ$  and  $70^\circ$ :

$$r = 100 - 3.0485 t + 0.04980 t^2 - 0.0003142 t^3.$$

For the proportion of 38.58 per cent of crystallised salt, between  $15^\circ$  and  $90^\circ$ :

$$r = 100 - 2.1272 t + 0.02539 t^2 - 0.0001179 t^3.$$

Solution of sulphate of copper with 26.49 per cent of the crystallised salt; between  $16^\circ$  and  $100^\circ$ :

$$r = 100 - 2.398 t + 0.02718 t^2 - 0.0001086 t^3.$$

The law of the alterations occurring simultaneously with the temperature and the degree of saturation, was found by Becker to be expressed between  $14^\circ$  and  $30^\circ$ , by the following formula, in which  $p$  signifies the amount of crystallised sulphate of copper contained in the solution.

$$\begin{aligned} r = 100.705 - 7.55128 p + 0.289896 p^2 - 0.00381569 p^3 \\ - (1.90774 - 0.10413 p + 0.0023508 p^2) t \\ + (0.014003 - 0.0001795 p) t^2 \\ - 0.00003968 t^3 \end{aligned}$$

Conduct-  
ing  
resistance.

In order to ascertain by means of these equations the absolute resistances of the respective liquids for different temperatures, they had to be found directly for each liquid, at least at one temperature. Becker has determined them both by Horsford's(1) method as well as by that proposed by Becquerel(2). We have here appended his results side by side with those of the previous observers, they are all reduced to the temperature of 20°, and corresponding degrees of saturation by means of Becker's formulæ. The resistance of nickel-silver is assumed at 1.

		Becker.	Horsford.	Becquerel.
Sulphuric acid . . .	1.24 sp. gr.	61430	56180	
Nitric acid . . . .	1.36 "	61430	—	76030
Sulphate of copper . .	20.83 per cent.	1.194.300	1.012.700	1.305.400
Sulphate of zinc . . .	38.58 "	888630		
.. . . .	64.50 "	819700		

Matteucci(3) has published a few preliminary notices of an investigation on the conducting power of liquids. As they contain nothing new of any consequence, and as the author has chosen a mode of communication which does not permit the reader to form a judgment on the value of the experiments, we are justified in reserving a detailed analysis until the appearance of a more complete treatise.

**Resistance of the Earth to Conduction.**—Double telegraphic wires, laid down between Vienna and Gänserndorf, as well as between Vienna, Gloggnitz and Gratz, have been used by Baumgartner(4) for measuring the resistance of the earth to conduction.—In all cases the resistances were very perceptible, but they did not increase in proportion to the length of the wires. The absolute magnitude of the resistance was invariably much smaller (from 3 to 6 times) than that exhibited by a copper wire of 1 Austrian line in thickness, and of a length equal to that of the piece of earth inserted. If the experiments were repeated, it would be interesting to determine separately the resistance which depends upon the polarisation and upon the small size of the plates, and which is found even when the plates that are sunk into the earth are only a few feet distant from one another. This resistance is by no means trifling, and when determined, it should be deducted from the entire resistance to conduction.

**Evolution of Heat in Conductors of Currents.**—A thin platinum wire, through which an electric current of constant strength is conducted, assumes, according to the gas which surrounds it, very un-

(1) Annual Report for 1847 and 1848, I, 219.

(2) Ibid. I, 222.

(3) Compt. Rend. XXIX, 806; Instit. 1850, 3; Arch. Ph. Nat. XIII, 142.

(4) Wien. Acad. Ber. June and July, 1849, 295; May, 28.

equal degrees of heat, although the evolution of heat in the interior of the wire must have remained the same in every case. This observation was first made by Grove(1). As hydrogen and some of its compounds especially exhibit a very remarkable cooling effect, the idea readily occurred that it was the consequence of the great mobility of these gases. However, certainly this is not the only cause of the phenomenon; for when Grove included two perfectly similar platinum wires in glass tubes of the same bore, one of which was filled with oxygen, the other with hydrogen, and then surrounded each tube with an equal weight of water, the fluid surrounding the hydrogen was least warmed, although the wire in the oxygen became white-hot, while the other became scarcely visibly incandescent(2).—Grove has not as yet discovered the cause of this remarkable effect.

**Luminous Arch.**—Matteucci(3) has repeated the well-known experiments of Neef on the luminous arch of the interrupted pile, but without adding anything of consequence. He states that the light proceeds mainly from the negative side only when the opposite positive point is of platinum, it being immaterial what metal is employed for the negative point. For the purpose of testing the differences of temperature, a small opening was made at the distance of 1 millimeter from the point, into which the welded ends of a thermo-electric pair were introduced. By the aid of this contrivance he confirmed the observation, that when two points of platinum, iron, lead or copper, are opposed to one another, the positive is more warmed than the negative point. But a very small difference only was observed when zinc or bismuth were employed.

Edward Staitc and Foucault have invented instruments intended to render the luminous arch permanent and constant. (See p. 92). The principle of the apparatus presented to the Paris Academy by Foucault, consists in employing the current which produces the luminous arch to magnetise an electro-magnet at the same time. This acts upon a piece of soft iron attached to a spring which also carries one of the charcoal-points. The spring is rendered tense by the attraction of the iron, and the charcoal-points are by this means separated. If the distance becomes too great the luminous arch is extinguished, but the magnet also loses its power, and the spring consequently restores the contact of the two points, the current is thus at once re-established and reproduces the luminous arch(4).

(1) Phil. Mag. Dec. 1845; Phil. Trans. for 1847, 1; Pogg. Ann. LXXI, 196.

(2) Phil. Mag. [3] XXXV, 114; Pogg. Ann. LXXVIII, 366; Instit. 1849, 151; Arch. Ph. Nat. XII, 265.

(3) Compt. Rend. XXIX, 263; Ann. Ch. Phys. [3] XXVII, 41; Instit. 1849, 290; Arch. Ph. Nat. XII, 5; Phil. Mag. [3] XXXV, 289.

(4) Compt. Rend. XXVIII, 68, 120, 698; Instit, 1849, 17, 44; Arch. Ph. Nat. X, 222 (in abstr.).

Luminous  
arch.

De la Rive(1) remarks on this point, that he has long since employed in his lectures a similar, but much less complicated, apparatus than that presented by Foucault to the Academy of Paris. It exactly corresponds to the above simple description. He states that he obtains a tolerably good luminous arch by this means. This apparatus is evidently nothing more than Neeff's contact-breaker on a large scale. The reporter is able to confirm De la Rive's statements by his own experience.

**Electrodynamics. Electrodynamic Rotation.**—Poggendorff(2) has been induced by a series of experiments on the well-known electrodynamic rotation of mercury, to examine more closely the conditions of the direction of this rotatory motion. He observed on this occasion, that Ampère's hypothesis in some cases, but certainly only when superficially employed, leads to contradictory results.—Poggendorff found that the rotation, after a certain period, invariably became more inert and soon entirely ceased, at least at the surface of the fluid metal. Even if the lustre was unchanged, the surface had then assumed that viscid condition which is well known to those physicists who have frequent opportunities of experimenting with mercury. Poggendorff explains this phenomenon, and no doubt rightly, by the mercury taking up oxygen.

**Induced Currents.**—Kirchhoff(3) has determined the constant which is required by the term(4) found by Neumann for the intensity of an induced current, in order to permit deriving the force of the induced from that of the inducing current.

By means of the magnetometer, Edlund(5), of Upsala, has measured the induced currents arising in the closing wire itself when galvanic circuits are opened and closed; he had previously succeeded in disposing his apparatus in such a manner as to get rid entirely of the influence exerted by the principal current upon the needle. He found that both currents are of equal strength when the inducing current-force is the same in both cases. The difference frequently observed arises from a diminution of the inducing current-force caused by the polarisation occurring in the pile. His experiments also, as might have been anticipated, have led to the conclusion, that the force of the two induced currents is proportional to that of the inducing current.

Henry, Professor of Physics in New Jersey, who was the first to observe(6) induced currents of higher orders, considers them, as well as those of the first order, as composed of two successive, opposed

(1) Arch. Ph. Nat. X, 222.

(2) Pogg. Ann. LXXVII, 1; Arch. Ph. Nat. XI, 222; Instit. 1849, 172.

(3) Pogg. Ann. LXXVI, 412.

(4) Berl. Acad. Ber. 1848.

(5) Pogg. Ann. LXXVII, 161.

(6) Ibid. Ergänzungsband I, 296, from Trans. of American Phil. Soc. VI.

currents. — Verdet(1) attempted to prove this assumption by the electro-chemical effect of these currents.

Induced  
currents.

For this purpose he employed two coils of wire, each consisting of two wires. A wire of the first (a,) conducted to the poles of an electric pile, the other (b,) was connected with the first wire (a,) of the second coil, whilst the second wire (b,,) of this coil was in connection with the platinum stripe of a voltametric apparatus. By the regular interruptions of the galvanic current traversing the wire a, currents were induced in b,. It was, however, so arranged, by means of a commutator, that only the directly induced current could circulate round the second coil. Nevertheless a mixture of oxygen and hydrogen was collected in the two glass bells of the voltameter, which proves that currents of opposite directions must have alternately passed through the voltameter.

We may fairly assume that the discharging current of the Leyden battery must, like every other electric current, produce an electrodynamic induction in a neighbouring closed conductor. The two currents thus generated are by analogy of equal strength and of opposite direction. It may be supposed likely that they would succeed one another so rapidly, as to render it impossible to observe them separately.—However, the inductive effect of the discharging current appeared to differ from that of other currents, for Henry, of New Jersey(2), and Riess(3) some time ago, independently of one another, made the discovery, that during the discharge of the Leyden battery a secondary current of the same direction as the primary one, is excited in a closed conductor placed in the vicinity of the closing wire. Riess(4) has subsequently minutely investigated the character and general deportment of this current.

The inductive effect of the discharging current has been lately made the subject of a scientific investigation by Verdet(5). He connected the ends of a spiral induction-wire which was most carefully isolated from the coils of the inductive spiral, with two platinum wires immersed in a solution of iodide of potassium. If one or the other induced current was in excess, both platinum wires must evidently be polarised in the direction of this excess.—In this case the polarisation must be demonstrable by the galvanometer. Now, if the induction-wire formed a circle that was closed by good conductors, no polarisation was perceptible during the most powerful discharges that were passed through the inductive spiral. But if the wire was interrupted at any point by a layer of air, so that a spark passed over, a very distinct polarisation was produced ; this was the

(1) Instit. 1849, 410.

(2) Pogg. Ann. Ergänzungs. I, 300.

(3) Ibid XLVII, 55.

(4) Ibid. XLIX, 393 ; L, 1 ; LI, 177.

(5) Ann. Ch. Phys. [3] XXIV, 377 ; Arch. Ph. Nat. X, 111 (in abstr.)

Induced  
currents.

more perceptible the greater the conducting resistance which had to be overcome, in the direction of an induced current of an analogous character. Rieß had previously arrived at similar results by a different proceeding. Hence it follows that the effect of the induced current, moving in the same direction, is in excess whenever considerable impediments have to be overcome during the circulation. "This," says Verdet, "proves that in the induced discharge of the same direction electricity possesses a greater velocity, and consequently for the time-unit must have a greater force than when the discharge is of an opposite character." Still both currents must be equal in absolute magnitude, as is apparent from their behaviour when the inductive spiral is well closed.

**Magneto-Electric Machine.**—Considerable improvements have recently been made in the magneto-electric machines. Sinstedden(1) and Stöhrer(2) have published instructive suggestions for rendering them more perfect. Stöhrer has employed these machines, as it appears, with a satisfactory result, for the purposes of the electric telegraph(3).

**New Source of Electric Excitation.**—Du Bois-Reymond has made the remarkable discovery that electric currents may be arbitrarily produced in the animal body, by a mere effort of the muscles. He connects the terminal points of a long multiplier-wire with stripes of platinum of exactly the same nature, and immerses them into two vessels containing salt-water. On introducing the corresponding finger of each hand into one of these vessels, and on exerting one arm to the utmost as soon as the needle has resumed the quiescent position, a current occurs directed from the hand to the shoulder; the needle is therefore deflected in opposite directions when first the one arm and then the other is worked. When this experiment was made known(4), several physicists attempted to repeat it, and not succeeding, looked upon the fact as doubtful; we instance Despretz(5), Becquerel, sen.(6), and Matteucci(7). To produce the effect, it is necessary to be provided with a very delicate galvanometer, and to be very careful in performing the experiment, as circumstances apparently trivial, *e. g.* the merest abrasion of one of the fingers that are immersed give rise to deception, and render the phenomenon doubtful, or even entirely obscure it.

The influence exerted by such accidental causes is diminished, and the experiment succeeds with less delicate galvanometers, if it be

(1) Pogg. Ann. LXXVI, 29, 195, 524.

(2) Ibid. LXXVII, 467.

(3) Ibid. 485.

(4) Pogg. Ann. LXXV, 463; Compt. Rend. XXVIII, 570, 641; XXIX, 8; Instit. 1849, 161, 210; Arch. Ph. Nat. XI, 218; Phil. Mag. [3] XXXIV, 543.

(5) Compt. Rend. XXV, 653; Instit. 1849, 169; Phil. Mag. [3] XXXV, 55.

(6) Compt. Rend. XXVIII, 663; Instit. 1849, 170; Phil. Mag. [3] XXXV, 53.

(7) Compt. Rend. XXVIII, 782; Instit. 1849, 202.

made by a larger number of persons who form into a chain with moistened hands; the last members close the circuit with the galvanometer-wire, by each immersing a finger into the vessels containing the salt-water. All are required to stretch the same arm, *e.g.* the right arm(1) at the same moment.

New  
source of  
electric  
excitation.

Du Bois-Reymond has, moreover, in a larger work(2), which has since become more generally known, investigated the conditions for the success of the fundamental experiment with such minuteness, and has at the same time exhibited so many relations of this electrical action to other phenomena of animal electricity, either previously known or discovered by the author, that there can no longer be any doubt as to the existence of this new source of electric excitation.

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(1) Ann. Ch. Pharm. LXX, 366; Phil. Mag. [3] XXXV, 288; Instit. 1850, 48; Arch. Ph. Nat. XIII, 149.

(2) Untersuchungen über thierische Electricität. Berlin, 1848 and 1849.



# INORGANIC CHEMISTRY.

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General-  
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Views re-  
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atomic  
weights  
and  
chemical  
formulae.

**Generalities. Views respecting Atomic Weights and Chemical Formulae.**—Laurent(1), in the introduction to a paper on the composition of the silicates, gives a summary of his views regarding atomic weights and chemical formulae. He adheres to the opinion that the same element may possess different atomic weights, that iron, for example, has, in the protoxide, the equivalent  $28 = \text{Fe}$ , while in the sesquioxide, to which he gives the formula  $\text{FeO}$ , its equivalent is  $18.6 = \text{Fe}$ . He consequently assigns to manganese, in its different combinations, not less than four different equivalents, symbols and names. In support of this view he has advanced the hypothesis that 1 equivalent of an element may contain in itself various numbers of single atoms, and that 1 equivalent of iron in the sesquioxide contains a number of atoms differing from that contained in 1 equivalent of iron in the protoxide, just as different quantities of carbon and hydrogen are contained in the formulae of acetic and butyric acids. Thus, 1 equivalent of Fe might contain 24, and 1 equivalent of Fe 16 separate atoms of iron, and of these atoms, composing one equivalent, several might also be replaced by atoms of other similar elements. Laurent considers that these views agree better with facts than those upon which the formulae hitherto employed are based, particularly with respect to the colour, specific heat and specific volume of the compounds; he also believes that the anomaly presented by the replacement (in the manganates and sulphates) of 1 equivalent of sulphur by 1 of manganese, and (in the permanganates and perchlorates) of 1 equivalent of chlorine by 2 of manganese, without change of form, is removed by the simple assumption that the manganese in the manganates has an atomic weight which differs from that in the permanganates. Laurent should not, however, have brought forward this argument, as he himself does not find any anomaly in the replacement of 2 equivalents of calcium by one of sodium, without change of form. Without entering here into the details of the arguments by which Laurent endeavours to prove the fallacy of the views and formulae hitherto adopted, we will merely remind the reader that the laws by which Laurent endeavours to refute the old formulae,

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(1) Laur. and Gerh. C. R. 1849, 257.

were actually arrived at by means of the latter, and that the view which he opposes, viz. that the equivalent of an element is the same in all its combinations, is the expression of a law which as yet remains quite unshaken, namely, the law of multiple proportions. This law is not by any means involved in Laurent's conception of this question. Laurent, moreover, defends the opinion that the oxides  $R_2O_3$ , which he expresses by the formula  $rO$ , may replace the oxides  $RO$  without inducing any change of form; he supports his view by the analysis of a few minerals, by which he means to prove that, in combinations containing both these kinds of oxides, the proportion of oxygen they contain is not a constant one, but that only the joint amount of their oxygen furnishes a starting-point for the detection of constant and simple relations. We have pointed out in our last Annual Report (Vol. II, 397) that this assertion received some support even from some of the more recent analyses; it may, however, be asserted with perfect justice in favour of the views hitherto adopted, that though many of the older analyses may not accord with it, yet nearly all the more recent and accurate determinations have contributed to its confirmation.

General-  
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Views re-  
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**Oxygen.**—A. Vogel, jun.,(1) has observed the presence of chlorine in the first portion of oxygen disengaged on heating chlorate of potassa. He considers it probable that it arises from traces of hypochlorite of potassa, adhering to the crystals of the chlorate. For the preparation of chemically pure oxygen from chlorate of potassa, he recommends that this salt should be purified as much as possible by repeated recrystallisation, and that the gas should be washed or passed through dilute alkalies, before it is used.—The presence of chlorine in oxygen, prepared from chlorate of potassa, and particularly from a mixture of that salt and binoxide of manganese, has also been observed by Poggendorff(2). Chevreul(3) found chlorine in oxygen obtained from a mixture of chlorate of potassa and protoxide of copper.

**Ozone.**—Schönbein(4) has published farther researches on ozone. In order to decide whether ozone must be considered as a peroxide of hydrogen, or as an allotropic modification of oxygen, he allowed well-dried ozonised air to pass through a red-hot glass tube, and afterwards through a weighed tube, containing pumice-stone, saturated with sulphuric acid. The ozone was destroyed in the red-hot glass tube, whilst the weight of the second tube was found not to be increased. This result is opposed to the opinion that ozone is a peroxide of hydrogen. Nevertheless, Schönbein does not adopt the other view, because he considers that the existence of an allotropic modification of gaseous

(1) *Repert. Pharm.* [3] III, 145.

(2) *Pogg. Ann.* LXXVII, 17.

(3) *Compt. Rend.* XXIX, 296.

(4) *Mémoire sur l'ozone*, Bâle, 1849; *Arch. Ph. Nat.* XII, 315 (in abstr.); *Ann. Ch. Pharm.* LXXII, 222.

Ozone.

bodies is inconceivable.—He also enters into the oxidation of various bodies, particularly of silver, by ozone. A plate of silver, when exposed in ozonised air, becomes rapidly covered with a black coating, which may be removed in the form of a film. This substance possesses a metallic taste, imparts an alkaline reaction to water when agitated with it, yields with hydrochloric acid chlorine and chloride of silver, and is decomposed at a red-heat, with evolution of oxygen, leaving a residue of 87 per cent of metallic silver, which amount corresponds to  $\text{Ag O}_2$ . Schönbein likewise directs attention to the formation of nitric acid, which always attends the production of ozone in atmospheric air, and which he considers as the effect of the action of ozone itself, and not as produced simultaneously with the latter, but resulting from the same causes that give rise to the formation of ozone. Well-washed ozonised air loses the odour of ozone when agitated with lime-water, and the latter is then found to contain nitric acid.

Schönbein(1) has published, moreover, some comparative experiments on ozone and binoxide of lead. He had already previously observed that both these bodies are capable of decomposing iodide of potassium with separation of iodine, of converting ferrocyanide into ferricyanide of potassium and of oxidising nitrous and sulphurous acids. He now calls attention to the following additional resemblances between these substances. Both decolourise organic colouring-matters; the binoxide of lead produces the effect by agitation with their solutions, whereby it is partially reduced to protoxide. Both exert an oxidising action upon metals; binoxide of lead, when agitated with water and finely divided tin, lead or arsenic, converts these metals into their oxides. Ozone and binoxide of lead are both decomposed by an aqueous solution of arsenious acid, the latter being converted into arsenic acid; both furnish with binoxide of manganese and dilute nitric or sulphuric acids, permanganic acid; with salts of the protoxide of manganese, the binoxide of that metal; both change the colour of ferrocyanide of iron and potassium to blue. Schönbein considers the analogous actions of chlorine and ozone on the one hand, and of that substance and binoxide of lead on the other, as a reason for viewing chlorine as analogous to binoxide of lead, or as containing oxygen, in accordance with the theory of Berthollet.

Osann(2) has examined the yellow precipitate obtained by passing ozonised air through a solution of protoxide of lead in potassa, which, with the exception of a very slight brown residual substance, is soluble in acetic acid. He found it to yield (0·0661 grm.), by reduction with hydrogen, 94·85 per cent of lead, while protoxide of lead contains 92·86 per cent of metal. By passing ozonised air through

(1) Pogg. Ann. LXXVIII, 162.

(2) Ibid. LXXVII, 592.

an ammoniacal solution of nitrate of silver, a black precipitate was produced, which, when dried, contained 97·56 per cent of silver, corresponding to the formula  $\text{Ag}_3\text{O}$ . In subsequent experiments(1) the silver-compound furnished from 97·20 to 97·35, or a mean of 97·26 per cent of silver. Assuming the silver-, as well as the lead-compound, to contain ozone, 1 equivalent combined with 2 of silver in the former compound, and 1 equivalent with 1 of lead in the latter, Osann calculates the atomic weight of ozone from the lead-compound at 5·63, and from the silver-compound at 6·10. In his opinion these determinations appear to indicate that ozone possesses a peculiar atomic weight, and that it is by no means a mere modification of oxygen, but a peculiar substance, like chlorine, bromine, &c., but that as yet it is undecided whether it be a simple or compound body.

**Carbon.**—Only a brief notice(2) has been published of an investigation of Stas, regarding the atomic weight of carbon. His endeavours to determine accurately the amount of carbonic acid, resulting from the combustion of a known weight of carbonic oxide, were unsuccessful. The quantity of oxygen (from protoxide of copper) taken up by an unknown amount of carbonic oxide, to form a known weight of carbonic acid, could however be ascertained with exactness. Stas is led, by these experiments, to the conviction that the atomic weight of carbon lies between 6·000 and 6·005.

Esprit(3) has made a collection of the observations hitherto published on the power of absorption which is exercised by carbon on salts in solution, on peculiar vegetable matters, &c., to which he has added some experiments of his own on this subject. The latter are not sufficiently new to require a special report. From some experiments instituted by Esprit to discover how far other porous bodies resembled carbon in this respect, it appears that pumice-stone exhibits no such absorptive power, while platinum-black removes the taste and colour from several tinctures, its power being however very soon exhausted. Esprit believes that this action of carbon is not solely dependent on its porosity, but on this and on a peculiar power of attraction which act simultaneously.

Schönbein(4) has stated, that aqueous sesquichloride of iron is converted, by agitation with charcoal-powder, into protochloride of iron; sulphate, acetate and nitrate of the sesquioxide of iron, into the salts of the protoxide, the latter, after having first been converted into the basic nitrate of the sesquioxide; protochloride of mercury into the subchloride, and nitrate of the protoxide of mercury into the salt of the suboxide. Solution of ferricyanide of potassium, after

(1) Pogg. Ann. LXXVIII, 98.

(2) Instit. 1849, 125.

(3) J. Pharm. [3] XVI, 192, 264; J. Pr. Chem. XLVIII, 124.

(4) Pogg. Ann. LXXVIII, 521.

Carbon-  
ates.

agitation with charcoal-powder, is stated to be coloured blue by a salt of the sesquioxide of iron.

**Carbonates.**—Sénarmont(1) has succeeded in preparing several carbonates with properties similar to those exhibited by the natural salts of this acid, by allowing them to form by double decomposition at a high temperature and under great pressure. The compounds which, by their action on each other, were to furnish the salts, were introduced into glass tubes, the latter were then exhausted and sealed. If the compounds were of such a nature as to act directly upon each other, they were introduced separately into the glass tube, and only subsequently mixed by inverting the tubes. By the action of sulphate of magnesia and carbonate of soda, at  $160^{\circ}$ , *carbonate of magnesia* was formed as a sandy, crystalline powder, scarcely attacked by dilute acids.—The result of the action of sulphate of protoxide of iron and carbonate of soda at  $150^{\circ}$  and higher, or of protochloride of iron and carbonate of lime, at temperatures between  $130^{\circ}$  and  $200^{\circ}$  maintained between 12 and 36 hours, was the formation of *carbonate of protoxide of iron* as a crystalline greyish-white sand, scarcely attacked by dilute acids, remaining almost unchanged in dry air, and assuming very gradually a light colour by exposure to moist air; its grey colour was darker, and its permanence on exposure to the air greater in proportion to the height and duration of temperature at which the formation was effected.—By the action of protochloride of manganese on carbonate of soda at  $160^{\circ}$ , or of protochloride of manganese on carbonate of lime, at temperatures ranging between  $140^{\circ}$  and  $170^{\circ}$ , and maintained from 12 to 48 hours, *the carbonate of protoxide of manganese* was formed, as a very fine amorphous powder, unchangeable at a gentle heat, and possessing a hue approaching to rose-colour.—The *carbonate of protoxide of zinc* was obtained in a similar manner as the iron-salt, in the form of a fine, white amorphous powder, unaltered by exposure to a gentle heat.

**Boron. Boracic Acid.**—A. Vogel, jun.,(2) recommends the following experiment for the elucidation of the difference in the brown colouring of tincture of turmeric by alkalies and by boracic acid. An alcoholic solution of the tincture, diluted with water till its colour is light yellow, is added to a concentrated solution of biborate of soda: the result will be the formation of a brown colour from the alkaline nature of the salt. The addition of some sulphuric acid will restore the yellow colour, but a larger quantity of this acid will again effect a brown colouring of the liquid by the liberation of the boracic acid, and after this time the colour will not disappear on the addition of more acid.

(1) Compt. Rend. XXVIII, 693; Instit. 1849, 177.

(2) Repert. Pharm. [3] III, 178.

**Borates.**—Laurent(1) has examined the borate of soda discovered by Bolley, to which the latter assigned the formula  $\text{NaO}, 4 \text{BO}_3 + 10 \text{HO}$ (2). According to Laurent, all borates are constituted according to the general formula  $\text{B}_2\text{O}_7 \text{R} + n \text{RO}$  (R representing an atom of hydrogen or metal, and  $n$  a whole number). The formula given by Bolley does not agree with this view. Laurent states that he was led, by many concordant analyses, to the formula  $5 \text{NaO}, 24 \text{BO}_3 + 52 \text{HO}$  for this salt; but that by fusing with it  $\frac{1}{10}$  of its weight of calc-spar, its amount of water was found to be higher, and its composition to be expressed by  $5 \text{NaO}, 24 \text{BO}_3 + 55 \text{HO}$ , or  $\text{B}_2\text{O}_7 \text{H} \frac{7}{12} \text{Na} \frac{5}{12} + 4 \text{HO}$ . He publishes, moreover, the formulæ of various borates lately investigated by him.—The equivalent of boron had been determined by Berzelius from the loss of water which occurs when biborate of soda is fused. According to Laurent, biborate of soda, when fused, still contains a small quantity of water, some hydrogen being generated when iron is added to the fused salt. He determined the amount of water in biborate of soda by fusing it with the addition of  $\frac{1}{10}$  its weight of calc-spar, and obtained by this means 47.15 to 47.20 per cent. (Berzelius had found 47.10 per cent.) From this determination Laurent calculates the equivalent of boron at 11.

**Borate of Lead.**—Thornton J. Herapath(3) has investigated the compounds of boracic acid with protoxide of lead. — *Neutral borate of lead* is obtained by precipitating a neutral lead-salt with a solution of biborate of soda, and digesting the precipitate for twelve or twenty-four hours with strong ammonia; it appears likewise to be formed by incomplete precipitation of basic acetate of lead by a solution of biborate of soda, or by supersaturation of an acid solution of one of the acid borates of lead, to be presently described, with strong ammonia. It forms a dense, amorphous, white powder, insoluble in water and alcohol, but easily soluble in dilute nitric acid or in boiling acetic acid, from which solutions it is reprecipitated unchanged by the addition of a considerable excess of ammonia; it is decomposed by sulphuric and hydrochloric acids, and boiling solutions of the fixed alkalis. Its formula is  $\text{PbO}, \text{BO}_3 + \text{HO}$ ; the water commences to escape at from  $120^\circ$  to  $150^\circ$ ; by continuing the heat from  $230^\circ$  up to  $260^\circ$  the salt becomes perfectly anhydrous, without changing its colour; when exposed to a red-heat before the blowpipe it yields a colourless glass of the sp. gr. 5.598.—*Sesquiborate of lead* is precipitated from a boiling solution of a lead-salt

(1) Compt. Rend. XXIX, 5; Instit. 1849, 209; J. Pr. Chem. XLVII, 412. A more detailed paper by Laurent on the borates (in his and Gerhardt's Compt. Rend. des Trav. Chim. 1850, 33), will be referred to in the next Annual Report.

(2) Comp. Annual Report for 1847 and 1848, I, 255.

(3) Phil. Mag. [3] XXXIV, 375; J. Pr. Chem. XLVII, 225; Ann. Ch. Pharm. LXXII, 254.

Borate of  
lead.

by the addition of a considerable excess of biborate of soda; it is a white powder, which has, when dried at  $100^{\circ}$ , the formula  $2 \text{ PbO}, 3 \text{ BO}_3 + 4 \text{ HO}$ , and loses 2 HO at from  $180$  to  $200^{\circ}$ ; it yields likewise, before the blowpipe, a colourless glass of the sp. gr. 5.235.—*Biborate of lead* is obtained by boiling one of the foregoing salts, when freshly precipitated and moist, with a concentrated solution of boracic acid. This salt forms, when dried at  $100^{\circ}$ , a light amorphous powder, having the formula  $\text{PbO}, 2 \text{ BO}_3 + 4 \text{ HO}$ , and containing only 1 HO when dried at from  $200$  to  $230^{\circ}$ ; it is fusible with difficulty at a red-heat to a vesicular glass.—If one of the foregoing salts be boiled with moderately strong nitric acid, and the solution concentrated until the liquid is saturated, and if it be then filtered and evaporated until a pellicle forms on its surface, it will deposit, upon cooling, irregular lustrous crystals, which, when heated above  $120^{\circ}$ , become opaque, decrepitate slightly, and evolve water and traces of nitrous fumes; when heated to redness, however, they form a colourless glass, with evolution of nitrous fumes. Herapath was not able to determine with certainty the composition of these crystals, he believes, however, that they are  $\text{PbO}, \text{BO}_3 + \text{PbO}, \text{NO}_5 + \text{HO}$ .—A compound of protochloride of lead and borate of lead, was once accidentally obtained by mixing a hot solution of biborate of soda with a boiling concentrated solution of protochloride of lead, filtering the mixture while hot, and washing the white flocculent precipitate, remaining on the filter, with lukewarm water. This precipitate consisted of microscopic acicular crystals; it was found to have the composition  $\text{PbO}, \text{BO}_3 + \text{PbCl} + \text{HO}$  when dried over sulphuric acid, and to become anhydrous by desiccation at from  $120$  to  $150^{\circ}$ . It was not decomposed by cold water, but by boiling water slowly into the two simple salts; it dissolved easily in hot dilute nitric acid, from which solution protochloride of lead was deposited upon cooling; it fused at a faint red-heat to a clear amber-coloured mass which furnished on cooling an almost colourless glass; when heated to redness on charcoal, or in an open platinum capsule, it fused with evolution of white fumes, became gradually more viscid, and formed, upon cooling, an opaque glass. Subsequent attempts to prepare this body again, proved unsuccessful.

**Phosphorus. Phosphoric Acid.**—L. Thompson<sup>(1)</sup> recommends, for the preparation of pure sulphuric acid (for Marsh's test) and of pure phosphoric acid, that finely-pulverised sulphate of lime or phosphate of lime be suspended in water, and decomposed by oxalic acid. By evaporation, the excess of the latter would be decomposed, and thus pure acids, more particularly free from metals, might be obtained.

**Phosphates.**—Kühn<sup>(2)</sup> has published a great number of experi-

(1) Pharm. J. Trans. VIII. 523.

(2) Arch. Pharm. [2] LIX, 129; Chem. Gaz. 1850, 28, 50.

ments on the weight and composition of the precipitates produced by common phosphate of soda in various soluble salts. The composition of these substances is for the most part but imperfectly studied, and most of the formulæ constructed by Kühn are exceedingly improbable; for the details of these experiments, of which an abstract cannot well be given, we must refer to the journals mentioned below.

**Phosphate of Soda.**—R. F. Marchand(1) has confirmed the formula  $2 \text{NaO}, \text{HO}, \text{PO}_5 + 24 \text{HO}$  as expressive of the amount of water contained in common phosphate of soda. This agrees with most of the analyses previously made of this salt, and contradicts Malaguti's statement, that it contains two equivalents more of water. Marchand found likewise that the salt, when crystallised at a low temperature ( $0^\circ$ ), contained the same amount of water.

**Phosphate of Lime.**—Bödeker(2) has published some researches on crystallised phosphates of lime and protoxide of manganese.—On precipitating a solution of chloride of calcium with a slight excess of phosphate of soda, dividing the solution and the precipitate into two equal parts, adding to one portion as much nitric or hydrochloric acid as is just requisite for dissolving the precipitate in the cold, then mixing it with the other portion, and allowing the mixture to stand quietly in the cold, the amorphous precipitate will, after the lapse of 48 hours, gradually change into delicate white laminæ, exhibiting under the microscope the form of very thin, tabular, rhombic prisms. These little laminae, when perfectly washed with water, have the formula  $2 \text{CaO}, \text{HO}, \text{PO}_5 + 4 \text{HO}$ (3); they lose no water by desiccation over chloride of calcium or sulphuric acid; at  $150^\circ$  they part with 4 equivalents, and with the fifth only at a red-heat; by boiling with water they are rendered porous, opaque, and are decomposed, with the formation of a solution of acid phosphate of lime.

**Phosphate of Protoxide of Manganese.**—By precipitating a solution of sulphate of protoxide of manganese with excess of phosphate of soda, and partially dissolving the precipitate in hydrochloric acid, Bödeker obtained by the same method as is described above with

(1) J. Pr. Chem. XLVI, 172.

(2) Ann. Ch. Pharm. LXIX, 206; Chem. Gaz. 1849, 138.

(3) Wöhler (Ann. Ch. Pharm. LI, 437) found that the concretions from the sturgeons of the Caspian Sea, known by the names of "belugen" stones, had the same composition. By passing carbonic acid into phosphate of lime freshly precipitated and suspended in water, Percy obtained fine scales (Phil. Mag. [3] XXVI, 194), by allowing the clear solution to evaporate spontaneously. To these crystals he had assigned the formula  $2 \text{CaO}, \text{HO}, \text{PO}_5 + 5 \text{HO}$ . He has now found (Chem. Gaz. 1849, 162) that he made an error in his statement regarding the amount of water contained in the salt, and that this compound is also represented by the formula  $2 \text{CaO}, \text{HO}, \text{PO}_5 + 4 \text{HO}$ . He states, moreover, that he has also obtained phosphate of magnesia in the same manner in the form of beautiful crystals, crumbling away in warm air, but that he has not yet analysed it.



Phosphate  
of protox-  
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reference to the lime-salt, the crystallised phosphate of protoxide of manganese in the form of plates almost colourless, exhibiting a slight light-red hue, highly lustrous, and partly recognisable by the naked eye as tabular regular rhombic prisms, the more acute prismatic edges being for the most part truncated. Their formula is  $2 \text{MnO}, \text{HIO}, \text{PO}_5 + 6 \text{HO}$ , and they are decomposed like the lime-salt by boiling with water.

**Phosphate of Alumina.**—H. Ludwig(1) has instituted some researches on the common-phosphate of alumina, and has arrived at the following results. The precipitate produced by an excess of common-phosphate of soda ( $2 \text{NaO}, \text{HO}, \text{PO}_5 + 24 \text{HO}$ ) in a solution of potassa-alum, is not sesquiphosphate of alumina, even in the freshly precipitated hydrated state, but after being properly washed with cold water, dried and heated, it is represented by the formula  $8 \text{Al}_2\text{O}_3, 9 \text{PO}_5$ . By dissolving in hydrochloric acid and precipitating by ammonia, this compound loses  $\frac{1}{8}$  of its phosphoric acid which remains in solution, together with a small quantity of alumina; the resulting precipitate, when dried in the air, contains ammonia; after ignition it corresponds in composition to the formula  $\text{Al}_2\text{O}_3, \text{PO}_5$ ; in the hydrated state (irrespective of the ammonia), it has the composition of gibbsite analysed by Hermann(2). By dissolving the  $\frac{9}{8}$  phosphate of alumina in hydrochloric acid, and precipitating the solution by an excess of acetate of soda at the boiling temperature a precipitate is obtained, which, when ignited, is either  $\text{Al}_2\text{O}_3, \text{PO}_5$ , or  $16 \text{Al}_2\text{O}_3, 15 \text{PO}_5$ ; from  $\frac{1}{8}$  to  $\frac{3}{16} \text{PO}_5$  remain in solution, but the whole of the alumina is contained in the precipitate. At the ordinary temperature when acetic acid is added to a solution of  $\frac{9}{8}$  phosphate of alumina in caustic soda, until a slightly acid reaction is exhibited, a precipitate is obtained corresponding after ignition to the formula  $16 \text{Al}_2\text{O}_3, 15 \text{PO}_5$ . When to a solution of  $\frac{9}{8}$  phosphate of alumina, or of  $\text{Al}_2\text{O}_3, \text{PO}_5$  in caustic soda, hydrosulphuric acid is added to saturation, or when an excess of sulphide of ammonium is employed, the alumina is precipitated as a very basic phosphate, more easily soluble in acetic acid than  $8 \text{Al}_2\text{O}_3, 9 \text{PO}_5$  or  $\text{Al}_2\text{O}_3, \text{PO}_5$ ; a great portion of the phosphoric acid remains in solution.

**Phosphate of Protoxide of Lead.**—Gerhardt(3) has published a more detailed account of his researches regarding the double salt of nitrate and phosphate of lead, which is formed on the addition of phosphate of soda to an excess of nitrate of lead. We have already communicated the most important points of this paper, in our preceding Report I, 262.

(1) Arch. Pharm. [2] LIX, 19.

(2) Comp. Annual Report for 1847 and 1848, II, 439.

(3) Laur. and Gerh. C. R. 1849, 234; Ann. Ch. Pharm. LXXII, 83.

**Double Phosphates.**—H. Rose(1) has published some researches on a series of insoluble double salts of common phosphoric acid, containing an alkali and an alkaline earth. These salts are formed with liberation of carbonic acid, by heating the pyrophosphate of an alkaline earth with an alkaline carbonate; it is difficult to obtain them pure. By employing an excess of the alkaline carbonate, the double-salt which is produced may undergo decomposition, and thus become mixed with the carbonate of the alkaline earth; if too small a quantity of the alkaline carbonate be employed, the resulting double-salt will contain an excess of the phosphate; the composition of these compounds depends partly upon the length of time that they are washed. They were generally prepared by intimately mixing 1 equivalent of the alkaline carbonate with 1 equivalent of the earthy pyrophosphate, and exposing the mixture to a red-heat, until it ceased to lose in weight; the ignited mass was neither fused nor aggregated by the heat employed; it was afterwards heated for some time with water, and then washed with hot water. The latter operation was in most cases a work of some time, and in some instances it was scarcely possible; in the latter cases, the alkali removed by washing was replaced by an equivalent of water. The double compounds, when washed as perfectly as possible, were dried at  $100^{\circ}$ ; they nearly all exhibited a crystalline structure under the microscope. Their preparation and analysis were conducted by Weber. The potassa-lime-salt, the soda-lime-salt, and the lithia-lime-salt, had a composition corresponding approximately to the proportions of 1 equivalent of alkali, and 2 equivalents of the earth, to 1 equivalent of phosphoric acid. In the case of the soda-lime-salt, it was necessary to employ the requisite proportions of pyrophosphate of lime and carbonate of soda in its preparation. The results obtained with the potassa-strontia-, the soda-strontia-, the potassa-baryta-, the soda-baryta-, the potassa-magnesia-, and the soda-magnesia-salts, exhibited greater discrepancies from the above proportions.—If mixtures of the earthy (pyro-) phosphates with the alkaline chlorides, be heated to redness, and the ignited masses exposed to moist air, chlorine will be expelled in the form of hydrochloric acid, and compounds, similar to those described above, will be formed; they are, however, not produced in the moist way, inasmuch as acid solutions, containing earthy phosphates, together with alkalis, yield, on addition of ammonia, a precipitate containing no alkali. There appears to exist another class of double phosphates, which are soluble in water, and contain perhaps 2 equivalents of alkali and 1 equivalent of an earth, to 1 equi-

(1) Pogg. Ann. LXXVII, 288; Berl. Acad. Ber. 1849, 181; J. Pr. Chem. XLVIII, 78; Instit. 1849, 529. Saussure and Berthollet have asserted that they produced a soluble and an insoluble double phosphate of potassa and lime in the moist way. (L. Gmelin's Handbook of Chemistry, Vol. III, 215.)

Double  
phos-  
phates.

valent of phosphoric acid; the existence of such salts would explain the fact, that when a mixture of an excess of pyrophosphate of soda with carbonate of lime is exposed to a dull red-heat, a mass is produced, the aqueous extract of which contains phosphate of lime.

**Metaphosphoric Acid.**—Some researches have been published by Fleitmann(1) on the various modifications of metaphosphoric acid. He first enters into the property of phosphoric acid in general, of assuming various modifications, and the twofold direction in which this property is exhibited, namely, in the formation of acids of the same composition but of different saturating capacity, and of acids differing in composition but possessing equal capacities of saturation, such as the different kinds of acids that have been recognised as modifications of metaphosphoric acid.

Fleitmann regards the various modifications of metaphosphoric acid as depending upon polymerism, and proposes a nomenclature in accordance with this view. He distinguishes

Monometaphosphoric acid in the compounds		$\text{PO}_5 + \text{RO}$
Dimetaphosphoric acid	" "	$2 \text{PO}_5 + 2 \text{RO}$
Trimetaphosphoric acid	" "	$3 \text{PO}_5 + 3 \text{RO}$
Tetrametaphosphoric acid	" "	$4 \text{PO}_5 + 4 \text{RO}$
Hexametaphosphoric acid	" "	$6 \text{PO}_5 + 6 \text{RO}$

Fleitmann determines the composition and name of any modification of metaphosphoric acid, chiefly from the proportion in which the bases are present in a double-salt of such an acid. The modification investigated by him and Henneberg(2) only forms double compounds containing 2 equivalents of one base to 1 equivalent of another, being represented by the general formula  $2 \text{RO}, \text{R'O} + 3 \text{PO}_5$ ; he therefore calls this acid trimetaphosphoric acid.

Fleitmann commences with examining the modifications of metaphosphoric acid in those salts which Maddrell(3) obtained as insoluble compounds, by heating a base, or one of its salts, with an excess of hydrated phosphoric acid. In endeavouring to decompose Maddrell's copper-salt with hydrosulphuric acid, Fleitmann found that this salt withstands the action of that acid with the greatest pertinacity; that it is, however, easily decomposed by a solution of sulphide of ammonium, and likewise, but with more difficulty, by the sulphides of sodium and potassium, salts being thereby formed which crystallise as easily as those of trimetaphosphoric acid, from which, however, they entirely differ. Fleitmann calls the acid contained in these salts *dimetaphosphoric acid*, as its double salts invariably con-

(1) Pogg. Ann. LXXVIII, 233, 338; Berl. Acad. Ber. 1849, 229 (in abstr.); J. Pr. Chem. XLIX, 224; Ann. Ch. Pharm. LXXII, 231; Instit. 1850, 75; Laur. and Gerh. C. R. 1850, 149.

(2) Comp. Annual Report for 1847 and 1848, I, 271.

(3) Comp. Annual Report for 1847 and 1848, I, 270.

tain 1 equivalent of one base to 1 equivalent of another, its compounds being consequently represented by the general formula  $2 RO + 2 PO_5$ .

Metaphosphoric acid.

According to Fleitmann, the salt which forms the starting-point in his investigation of metaphosphoric acid, viz., Maddrell's metaphosphate of copper, is obtained with the greatest certainty in the following manner: For 5 equivalents of phosphoric acid (in the form of a standard solution) 4 equivalents of protoxide of copper are taken. When the salt is to be prepared on a small scale, the oxide is employed in the form of the nitrate, but in more extensive preparations, finely powdered pure protoxide of copper is employed. In the latter case, the combination of the protoxide with the solution of phosphoric acid must be effected as perfectly as possible before the mixture is evaporated and exposed to heat; this is much facilitated by the addition of a little nitric acid. The clear solution of the protoxide in the solution of phosphoric acid soon becomes turbid during evaporation, the syrupy mass first deposits an intensely blue amorphous salt of common phosphoric acid,  $2 CuO, HO, PO_5$ , which redissolves partially on the farther application of heat, when a light-blue pulverulent pyrophosphate of copper  $2 CuO, PO_5$  is separated; on raising the temperature still higher, the mass will spirt violently, and the *dimetaphosphate of protoxide of copper* will begin to form. During its separation, it must be diligently removed from the sides of the vessel by means of a platinum spatula. The temperature is raised to about  $350^\circ$ ; the operation is completed when the excess of metaphosphoric acid commences to volatilise in dense clouds of vapour. The salt obtained in this manner is washed with water, as long as the washings exhibit a reaction on litmus paper. The dimetaphosphate of copper is obtained by this method as a pulverulent indistinctly crystalline substance; it may be obtained more distinctly crystalline by employing rather more phosphoric acid than the proportion given above, and by allowing the salt, which at the full red-heat of a Berzelius' lamp, is redissolved in the excess of phosphoric acid, to cool very gradually, and in such a manner that the excess of phosphoric acid may evaporate freely. The salt then separates in small lustrous crystals, particularly if the mass be gently agitated with a platinum spatula. The dimetaphosphate of copper,  $2 CuO, 2 PO_5$ , is bluish-white, insoluble in water, nearly insoluble in most acids and alkalis, even when concentrated. But it is dissolved pretty easily by ammonia, and by concentrated sulphuric acid, when heat is applied; in the latter case, the acid is at the same time converted into common phosphoric acid. (On the copper-salt, compare moreover p. 161.)

Dimetaphosphate of copper is hardly decomposed by solution of sulphide of sodium in the cold, but with great facility at an elevated temperature (even below the boiling-point). The liquid, filtered off from the sulphide of copper, and freed from any sulphide of sodium

Metaphos-  
phoric  
acid.

by digestion with finely-powdered dimetaphosphate of copper, cannot be made to crystallise on cooling; by evaporation, it yields indistinct (acicular) crystals, and, by gradual addition of alcohol, fine long needles of *dimetaphosphate of soda*. Their formula is  $2 \text{NaO}$ ,  $2 \text{PO}_5 + 4 \text{HO}$ ; they dissolve in 7.2 parts of water, are insoluble in strong alcohol, and scarcely soluble in very dilute spirit; they lose the whole of their water at  $100^\circ$ ; the anhydrous salt re-assimilates water with avidity, when exposed to the air, or moistened, with disengagement of heat. The salt fuses at a faint red-heat, and when rapidly cooled, yields common uncrystallised metaphosphate of soda. The solution of this salt is neutral, and may be preserved in the cold without decomposition; it becomes acid by lengthened ebullition, and the acid passes over into common phosphoric acid; this transition is rapidly effected by boiling the salt with acids.—*Dimetaphosphate of potassa* is obtained in the same manner as the soda-salt, in crystals which contain  $2 \text{KO}$ ,  $2 \text{PO}_5 + 2 \text{HO}$  and dissolve in 1.2 of cold or hot water. This salt becomes perfectly insoluble in water and weak acids, by exposure to a dull red-heat, or by fusion which takes place at the commencement of a red-heat; it then contains the same acid as the insoluble metaphosphate of soda.—*Dimetaphosphate of ammonia* is prepared in the same way as the two preceding salts; the decomposition of the copper-salt by sulphide of ammonium is greatly accelerated by the addition of a slight excess of caustic ammonia. The salt crystallises in the anhydrous state ( $2 \text{NH}_4\text{O}$ ,  $2 \text{PO}_5$ ) in short prisms, belonging to the monoclinometric system; it dissolves in 1.15 of cold and hot water, and is more easily soluble in dilute spirit than the potassa- or soda-salt. Hence, tolerably concentrated aqueous solutions must be employed in order to obtain crystals by means of alcohol. If the crystals are exposed for a lengthened period to a temperature of from  $200^\circ$  to  $250^\circ$ , they become white and opaque at the edges without undergoing any loss in weight, the acid passing over into the modification contained in the insoluble metaphosphate of soda; the whole of the ammonia cannot be expelled even by a bright red-heat.

On mixing any of the preceding soluble alkali-salts with an excess of nitrate of silver, *dimetaphosphate of silver* is deposited as a crystalline precipitate, or in crystals when dilute solutions are employed, having the formula  $2 \text{AgO}$ ,  $2 \text{PO}_5$ . This silver-salt fuses at a faint red-heat, and solidifies to a clear, transparent glass, perfectly insoluble in water.—*Dimetaphosphate of lead* corresponds to the silver-salt in its composition and mode of preparation; it always contains a slight admixture of nitrate of lead, from which it cannot be purified by treatment with water.—*Dimetaphosphate of baryta* separates, on the addition of an excess of chloride of barium to a tolerably concentrated solution of the soda-salt, sometimes in small acicular crystals; by employing dimetaphosphate of potassa, a slightly crystalline precipitate immediately forms, which is soluble with great difficulty in water,

and is but slightly attacked by acids, even when boiled with them, with the exception of concentrated sulphuric acid. The crystallised salt is  $2 \text{BaO}, 2 \text{PO}_5 + 4 \text{HO}$ , the water is not perfectly expelled even at  $150^\circ$ ; it is therefore analogous in composition to dimetaphosphate of baryta, from which it differs, however, by yielding dimetaphosphate of soda, by digestion with carbonate of soda, while on the other hand, the baryta-salt furnishes trimetaphosphate of soda.—*Dimetaphosphate of lime* separates, on mixing dimetaphosphate of potassa, or of soda, with an excess of chloride of calcium, as a crystalline precipitate of the composition  $2 \text{CaO}, 2 \text{PO}_5 + 4 \text{HO}$ . If the ammonia-salt is employed for its preparation, a double-salt is intermixed with it.

Metaphosphoric acid.

On adding sulphate of copper to a concentrated solution of dimetaphosphate of soda, the mixture remains clear for some time; by evaporation in the air, or by addition of alcohol, the *dimetaphosphate of copper* is deposited, which, when once formed, is perfectly insoluble. A mixture of tolerably concentrated solutions of protochloride of copper, and dimetaphosphate of soda, deposits after standing some time, or on the addition of a small quantity of alcohol, small roundish crystals of  $2 \text{CuO}, 2 \text{PO}_5 + 8 \text{HO}$ .—In a similar manner *dimetaphosphate of protoxide of manganese* may be obtained as reddish-white crystals, and *dimetaphosphate of zinc* in colourless crystals, both corresponding in composition to the above salt,  $2 \text{RO}, 2 \text{PO}_5 + 8 \text{HO}$ . The crystallised *dimetaphosphate of magnesia*, which is prepared in a similar manner, appears to be  $2 \text{MgO}, 2 \text{PO}_5 + 9 \text{HO}$ . The compounds of dimetaphosphoric acid with strontia, protoxide of iron, protoxide of nickel, and protoxide of cobalt, may be obtained in the same way; they have, however, not been submitted to closer examination.

Dimetaphosphoric acid exhibits a great tendency to form double-salts which invariably contain equal equivalents of the two bases. On mixing concentrated solutions of the potassa- and soda-salts with chloride of potassium or chloride of sodium, a crystalline powder of *dimetaphosphate of potassa-soda*, separates either immediately or after a little time; it may be obtained in larger crystals by evaporating the aqueous solution. When crystallised, it is  $\text{NaO}, \text{KO}, 2 \text{PO}_5 + 2 \text{HO}$  (the water is only expelled partially even at  $150^\circ$ ); it dissolves in 24 times its weight of water. By mixing solutions of the soda- and ammonia-salts, and allowing the mixture to crystallise by spontaneous evaporation or addition of alcohol, crystals of the *dimetaphosphate of soda-ammonia*  $\text{NaO}, \text{NH}_4\text{O}, 2 \text{PO}_5 + 2 \text{HO}$  are formed, which lose the whole of their water of crystallisation at  $110^\circ$ . Various salts crystallise successively from a mixture of solutions of equal equivalents of the potassa- and ammonia-salts; Fleitmann considers the first of these to be  $2 \text{KO}, 2 \text{PO}_5 + 2 \text{HO}$ , in which a portion of the KO is replaced by  $\text{NH}_4\text{O}$ , and the salt that is last deposited as

Metaphos-  
phoric  
acid.

$2 \text{NH}_4\text{O}$ ,  $2 \text{PO}_5$ , in which a portion of the  $\text{NH}_4\text{O}$  is replaced by  $\text{KO}$ . If the insoluble dimetaphosphate of lead, described above (page 160), is treated with an excess of dimetaphosphate of ammonia, it is converted into small distinct crystals of *dimetaphosphate of lead-ammonia*. This salt separates likewise immediately on mixing nitrate of lead with a sufficient excess of dimetaphosphate of ammonia; when dried in the air, it has the formula  $\text{PbO}$ ,  $\text{NH}_4\text{O}$ ,  $2 \text{PO}_5$ ; it is with difficulty soluble in water, is difficultly attacked by acids, and does not lose in weight at  $150^\circ$ . A double-salt of protoxide of lead and soda is obtained in a similar manner, which is, however, soon decomposed again, and did not furnish concordant results on analysis.—The precipitate furnished by chloride of calcium with dimetaphosphate of ammonia always contains ammonia; by employing an excess of the latter salt, and crystallising by means of alcohol, *dimetaphosphate of lime-ammonia* is obtained in spear-like crystalline laminae of the formula  $\text{CaO}$ ,  $\text{NH}_4\text{O}$ ,  $2 \text{PO}_5 + 2 \text{HO}$ , which are with difficulty soluble in water.—A mixture of tolerably concentrated solutions of 2 equivalents of dimetaphosphate of ammonia, and 1 equivalent of protochloride of copper, deposits, on addition of alcohol, *dimetaphosphate of copper-ammonia* in confused masses of blue acicular crystals, whose composition may be generally represented by the formula  $\text{CuO}$ ,  $\text{NH}_4\text{O}$ ,  $2 \text{PO}_5 + 4 \text{HO}$ . This salt loses part of its water of crystallisation at the common temperature, and half at  $100^\circ$ . In certain circumstances, it crystallises with only one-half of the above amount of water of crystallisation, and in that state it is a stable salt.—There exist, besides, many other double-salts of dimetaphosphoric acid, which have, however, been less perfectly investigated.

On heating a compound of the protoxide of manganese with excess of phosphoric acid, an *anhydrous dimetaphosphate of manganese* is formed in exactly the same manner as the dimetaphosphate of copper (page 150); this salt is pink, and possesses the same characteristic insolubility as the copper-salt; it is but slightly attacked by the alkaline sulphides, and yields, on digestion with a solution of carbonate of soda, dimetaphosphate of soda. *Anhydrous dimetaphosphate of zinc* is obtained in the same manner as a white indistinctly crystalline powder; it redissolves in an excess of phosphoric acid, when heated to redness with it, and may be obtained from this solution in small distinct crystals, by allowing it to cool slowly, and stirring it diligently.

It could not be ascertained what modifications of metaphosphoric acid existed in the compounds of the protoxides of cobalt and nickel, of magnesia, baryta, strontia, and lime, prepared according to the same method, and which are all represented by the empirical formula  $\text{RO}$ ,  $\text{PO}_5$ , as Fleitmann was unsuccessful in his endeavours to combine the acid they contained with other bases.

When protoxide of lead is heated with phosphoric acid, the salt that

separates redissolves in an excess of the acid, before it can be assumed with certainty that it is actually a metaphosphate. On allowing the clear fused mixture to cool gradually, large transparent prismatic crystals are, however, obtained, which contain equal equivalents of protoxide of lead and phosphoric acid; they are almost perfectly insoluble in water, and are decomposed, by boiling with acids, more readily than the insoluble metaphosphates above described. This salt is easily decomposed by alkaline sulphides in the cold, with the formation of uncrystallisable alkali-salts. The soda-salt thus produced is tough and elastic when combined with water, and forms, with a large quantity of the latter, a slimy mass, which will not alter; when dried, it is a transparent granular mass, which is not hygroscopic. These alkali-salts give elastic precipitates with the alkaline earths. Fleitmann considers it probable that the acid, contained in the above lead-salt, and in these alkali-salts, is *tetrametaphosphoric acid*, and that the general formula of these salts is  $4\text{RO}, 4\text{PO}_5$ . On fusing together dimetaphosphate of copper with more than its equivalent of dimetaphosphate of soda, and allowing the mass to cool down gradually, three salts are deposited: trimetaphosphate of soda, which may be easily extracted by water, dimetaphosphate of copper, and a double-salt, containing tetrametaphosphoric acid. The deposition of the two first may be prevented by the addition, on fusing the mixture, of about one-fourth as much free phosphoric acid as is contained in the dimetaphosphates employed, and heating to  $300^\circ$ ; the double-salt  $2\text{CuO}, 2\text{NaO}, 4\text{PO}_5$  separates, at this temperature, as a bluish-white, indistinctly crystalline powder, which yields, on digestion with solution of sulphide of sodium, the elastic tough soda-salt. The latter is likewise formed by the action of sulphide of sodium on the insoluble salts, obtained by heating the teroxide of bismuth, or protoxide of cadmium, with an excess of phosphoric acid. Protoxide of silver fuses, with an excess of phosphoric acid, to a clear glass, with the same ease as protoxide of lead; the mixture, when gradually cooled, deposits with difficulty small lustrous crystalline scales which are insoluble in water, and are easily decomposed by a solution of sulphide of sodium, with the formation of the common (deliquescent) metaphosphate of soda.

The latter salt yields, when mixed with an excess of chloride of ammonium, and afterwards with alcohol, a syrupy precipitate, in which soda and ammonia are contained in very variable proportions. Fleitmann considers it probable that the common (deliquescent) metaphosphate of soda may contain *hexametaphosphoric acid*, the compounds of which are represented by the general formula  $6\text{RO}, 6\text{PO}_5$ .—He views the acid, contained in the insoluble alkaline metaphosphates, as *monometaphosphoric acid*, as it does not appear to form double salts.

The following would be a general view of the formation of the



Metaphosphoric  
acid.

various modifications of metaphosphoric acids, as adopted by Fleitmann: *monometaphosphoric acid* is produced by the action of the three alkalis; it is always formed when equal equivalents of potassa and phosphoric acid are ignited together; it is obtained in combination with ammonia, by heating dimetaphosphate of ammonia to  $250^{\circ}$ . *Dimetaphosphoric acid* is produced by heating together equal equivalents of phosphoric acid and protoxide of copper, protoxide of zinc, or protoxide of manganese.—*Trimetaphosphoric acid* is only formed in the crystallisation of a fused mixture of equal equivalents of phosphoric acid and soda, by allowing it to cool gradually.—*Tetrametaphosphoric acid* is produced by the action of protoxide of lead, teroxide of bismuth, and protoxide of cadmium, or a mixture of equal equivalents of protoxide of copper and soda.—*Hexametaphosphoric acid* is formed by the ignition of hydrate of phosphoric acid, by the rapid cooling of the fused soda-salt, and by the action of protoxide of silver.

In conclusion, Fleitmann inquires, why the action of different bases on phosphoric acid should produce various modifications of metaphosphoric acid. He believes this to be dependent on the circumstance that bases have a tendency to combine under certain conditions with either 1, 2, or more equivalents. Thus, for instance, protoxide of copper is endowed with the capacity and tendency to form double atoms in preference to other compounds.

**Combinations of Phosphorus with the Halogens.**—Gladstone(1) has made some researches on the combinations of phosphorus with halogens. Terchloride of phosphorus may be obtained by the action of phosphorus on the chlorides of copper and iron, but not by its action upon protochloride of lead. Pentabromide of phosphorus is decomposed at  $100^{\circ}$ , and by the action of a current of dry air into terbromide of phosphorus and free bromine.—*Oxibromide of phosphorus*,  $PBr_3O_2$ , is obtained by decomposing the pentabromide of phosphorus by moist air, heating the resulting reddish viscid fluid, to expel the hydrobromic acid, and distilling it at about  $180^{\circ}$ , when it passes over as a colourless, dense liquid, boiling between  $170^{\circ}$  and  $200^{\circ}$ . It is not miscible with water, by which it is however slowly decomposed into phosphoric and hydrobromic acids, accompanied generally by the formation of a small quantity of a brown, resinous substance; it is soluble in oil of turpentine, ether and concentrated sulphuric acid, and may be reprecipitated from the latter solution by water; it is decomposed by nitric acid, with evolution of bromine. A compound of apparently the same composition as the fluid oxibromide of phosphorus, was formed several times in small quantities, under circumstances not thoroughly investigated, in the distillation of terbromide or oxibromide of phosphorus (when it remained behind

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(1) Phil. Mag. [3] XXXV, 345; J. Pr. Chem. XLIX, 40.

in the retort) and by the action of the air on imperfectly closed pentabromide of phosphorus. It forms colourless crystals, which are decomposed by water; it fuses and evaporates at a moderate temperature; it does not, however, re-solidify on cooling, but remains as a fluid possessing the properties of oxibromide of phosphorus. By the action of dry hydrosulphuric acid on pentabromide of phosphorus, a dense liquid is produced, which boils at about  $200^{\circ}$  without undergoing decomposition, and the composition of which was found to correspond approximately to the formula,  $3 \text{ PBr}_3 + \text{PS}_3$ ; Gladstone has however left it undecided whether this body is not a mixture of two different substances, possessing nearly the same boiling-point.

Combina-  
tions of  
phos-  
phorus  
with the  
halogens.

**Pentachloride of Phosphorus.**—Persoz and Bloch have published some short notes on the compounds of pentachloride of phosphorus with various acids.—In their first communication(1) they state the following facts. By the action of concentrated nitric acid on pentachloride of phosphorus there is formed, besides phosphoric acid, a compound containing chlorine, nitrogen and oxygen. Nitrous acid and pentachloride of phosphorus form anhydrous phosphoric acid, and a complicated combination of chlorine, nitrogen and oxygen. The action of nitric acid, or nitrous acid, upon trichloride of phosphorus is attended by very violent explosions. By passing the vapours of pentachloride of phosphorus over sulphate of protoxide of mercury, heated in a glass tube, the compound  $\text{PCl}_5 + \text{SO}_3$  (*chlorophosphate acisulfurique*) is formed; this compound is liquid at the ordinary temperature, and possesses a constant boiling-point; it is decomposed, when heated with water, into sulphuric, phosphoric, and hydrochloric acids. If pure and dry sulphurous acid be passed into pentachloride of phosphorus, these two substances combine to form a white volatile liquid(2), which, when pure, has the composition  $\text{PCl}_5 + 2 \text{ SO}_2$  (*chlorophosphate biacisulfureux*); this compound is decomposed by water into phosphoric, hydrochloric, and sulphurous acids. By passing the vapour of pentachloride of phosphorus over a layer of anhydrous phosphoric acid, these substances combine, forming a colourless liquid, which probably is  $\text{PCl}_5 + \text{PO}_5$  (*chlorophosphate aciphosphorique*), and is decomposed by water into hydrochloric and

(1) Compt. Rend. XXVIII, 86.

(2) This compound was also obtained and subjected to a closer examination by Kremers. He states that on passing dry sulphurous acid over pentachloride of phosphorus, a great amount of heat is liberated, and a greenish-coloured fluid is formed, which evolves a little sulphurous acid upon rectification. The distillate has the composition  $\text{PCl}_5 + 2 \text{ SO}_2$ ; its sp. gr. is 1.667 at  $14^{\circ} \text{ C}$ , its boiling-point  $100^{\circ} \text{ C}$ ; it is pellucid, attracts water with avidity, violently attacks the eyes and respiratory organs, and refracts light powerfully. It dissolves iodine, with a red colour, and also pentachloride of phosphorus, pretty readily; the latter crystallises out again, almost completely, after some time, at the ordinary temperature, in transparent four-sided plates. When treated with sulphurous acid, this distillate absorbs another equivalent, which escapes again, however, at the ordinary temperature. (Ann. Ch. Pharm. LXX, 297.)

Penta-  
chloride of  
phos-  
phorus.

phosphoric acids(1).—In a second communication(2) they state that they have obtained, moreover, the following compounds: a combination of pentachloride of phosphorus with tungstic acid  $\text{PCl}_5 + \text{WO}_3$  (*chlorophosphate acitungstique*), which is liquid above  $0^\circ$ , but crystallises in laminae by immersion in a freezing mixture of ice and salt, and boils at  $95^\circ$ ; a liquid uncrystallisable compound of pentachloride of phosphorus with arsenious acid, boiling at  $110^\circ$ ; a complex liquid substance, boiling at  $85^\circ$ , and prepared by the action of pentachloride of phosphorus on bisulphide of arsenic (realgar).

**Metallic Phosphides.**—Schrötter(3) has made some communications on the compounds of phosphorus with metals, obtained by direct combination. The metals were employed, as far as possible, in the state of fine powder, as obtained by reduction with hydrogen; they were introduced, on a small porcelain boat, into a glass tube, closed at the lower extremity by mercury, and filled with phosphorus-vapour, and then gradually heated until action ensued. It was necessary, in some cases, to pulverise the combination resulting from the first action, and to heat it once more in phosphorus-vapour.—Palladium, platinum, nickel, cobalt, iron, copper, manganese and iridium enter into combination with phosphorus, at a temperature somewhat below a red-heat, accompanied by a lively evolution of light; the combination of zinc and tin is not attended by this phenomenon; their combinations, as well as those of the first-named metals, with phosphorus, are not decomposed at a higher temperature. Silver and gold also combine with phosphorus without evolution of light, the resulting combinations are however decomposed at a higher temperature. The following compounds were submitted to a closer examination: *phosphide of palladium*,  $\text{PdP}$ , silvery-white, brittle and crystalline; sp. gr. 8.25, attracts moisture from the air, by which it is completely decomposed, is easily soluble in nitric acid, and only slightly acted on by hydrochloric acid. *Phosphide of platinum*,  $\text{PtP}$ , grey, possessing metallic lustre; sp. gr. 8.77, does not attract moisture from the air, is not soluble in hydrochloric acid, but easily so in nitrohydrochloric acid. *Phosphide of nickel*,  $\text{Ni}_3\text{P}$ , is whiteish-grey, crystalline, possessed of high metallic lustre; its sp. gr. is 5.99; it is insoluble in hydrochloric acid, and easily soluble in nitric acid. *Phosphide of cobalt*,  $\text{Co}_3\text{P}$ , is similar to phosphide of nickel; its sp. gr. is 5.62. *Phosphide of copper*,  $\text{Cu}_4\text{P}$ , is formed by the repeated action of phosphorus upon copper; by lengthened fusion in a perfectly closed crucible, filled with carbon, it is converted into  $\text{Cu}_6\text{P}$ , which is lustrous, brittle, has the sp. gr. 6.75, is but slightly altered by hydrochloric acid, and easily

(1) Gerhardt (in his and Laurent's *Compt. Rend. des Trav. Chim.* 1850—51) believes this compound to be nothing else than oxichloride of phosphorus ( $\text{PCl}_3\text{O}_2$ ).

(2) *Compt. Rend.* XXVIII, 389.

(3) *Wien. Acad. Ber.* May, 1849, 301.

dissolved by nitric acid. Besides these, Schrötter examined *phosphide of iron*,  $\text{Fe}_2\text{P}$ ; *phosphide of manganese*,  $\text{Mn}_3\text{P}$ , sp. gr. 4.94, insoluble in hydrochloric, but readily soluble in nitric acid; *phosphide of iridium*,  $\text{IrP}$ ; *phosphide of zinc*,  $\text{Zn}_3\text{P}$ , grey, sp. gr. 4.76, easily soluble in hydrochloric acid; *phosphide of tin*,  $\text{Sn}_2\text{P}$ , perfectly white, highly divisible and brittle, sp. gr. 6.56, easily soluble in hydrochloric acid, not acted on by nitric acid; *phosphide of silver*,  $\text{Ag}_3\text{P}$ , which is obtained with difficulty, as the phosphorus is expelled again if the temperature be a little too high; it is blackish-grey, has the sp. gr. 4.63, is insoluble in hydrochloric acid, and easily soluble in nitric acid; and *phosphide of gold*,  $\text{Au}_2\text{P}_3$ , which requires the same precautions in its preparation; it is grey, its sp. gr. is 6.67, it is not attacked by hydrochloric acid, nitric acid oxidises the phosphorus, leaving the gold behind.

**Sulphur.**—Brame(1) has published some researches and views with reference to the different states of sulphur, concerning which we must refer to the original communication. They are in accordance with his views of an utricular state of matter(2), and do not contribute much to extend our present positive knowledge with regard to sulphur. Brame assumes that sulphur can only exist in two different states; he has, however, deferred to a future period the more definite exposition of his views on this point.

**Hyposulphite of Soda.**—A paper published by Faget(3) on the preparation of hyposulphite of soda, contains nothing new worthy of note.

**Sulphurous Acid.**—Danson(4) has investigated several salts of sulphurous acid.—He prepared *sulphite of potassa* by passing the acid into an aqueous solution of potassa, until the liquid smelt powerfully of the gas; the liquid, mixed with ether, in a perfectly closed vessel, deposited, during a period of some weeks, a white crystalline precipitate, containing an amount of sulphurous acid corresponding to the formula  $\text{KO}, \text{SO}_2 + \text{HO}$ .—By passing sulphurous acid into water, containing freshly precipitated sesquioxide of chromium in suspension, until a clear green solution was formed, and subsequently boiling the latter, Danson obtained *sulphite of sesquioxide of chromium* as a green powder, of the composition  $2 \text{Cr}_2\text{O}_3, 3 \text{SO}_2 + 16 \text{HO}$ .—*Sulphite of lithia* was prepared by the action of sulphurous acid upon carbonate of lithia, suspended in water, and adding alcohol to the resulting solution, or boiling it, when white feathery crystals,  $\text{LiO}, \text{SO}_2 + 6 \text{HO}$ , were deposited.—*Sulphite of teroxide of bismuth*

(1) Instit. 1849, 394.

(2) Compare p. 7 of this Annual Report.

(3) J. Pharm. [3] XV, 333.

(4) Chem. Soc. Qu. J. II, 205; Ann. Ch. Pharm. LXXII, 228; Laur. and Gerh. C. R. 1849, 243.

Sulphu-  
rous acid.

was prepared by the lengthened action of aqueous sulphurous acid on freshly precipitated teroxide of bismuth (assisted by frequent agitation); the resulting straw-coloured precipitate became nearly white when dried; its formula is  $\text{BiO}_3, \text{SO}_2$ .

**Sulphuric Acid.**—With reference to the preparation of sulphuric acid, compare page 154.

Bineau(1) has arranged the results of his former experiments(2) on the sp. gr. of mixtures of sulphuric acid and water, in the form of the annexed table, A representing the sp. gr. in degrees according to Baumé's areometer, B the sp. gr., water being taken as unit, C the percentage of the monohydrated, and D of anhydrous sulphuric acid.

A	B	at 0°		at 15°		A	B	at 0°		at 15°	
		C	D	C	D			C	D	C	D
5°	1.036	5.1	4.2	5.4	4.5	50°	1.530	61.4	50.1	62.6	51.1
10	1.075	10.3	8.4	10.9	8.9	51	1.546	62.9	51.3	63.9	52.2
15	1.116	15.5	12.7	16.3	13.3	52	1.563	64.4	52.6	65.4	53.4
20	1.161	21.2	17.3	22.4	18.3	53	1.580	65.9	53.8	66.9	54.6
25	1.209	27.2	22.2	28.3	23.1	54	1.597	67.4	55.0	68.4	55.8
30	1.262	33.6	27.4	34.8	28.4	55	1.615	68.9	56.2	70.0	57.1
33	1.296	37.6	30.7	38.9	31.8	56	1.634	70.5	57.5	71.6	58.4
35	1.320	40.4	33.0	41.6	34.0	57	1.652	72.1	58.8	73.2	59.7
36	1.332	41.7	34.1	43.0	35.1	58	1.671	73.6	60.1	74.7	61.0
37	1.345	43.1	35.2	44.3	36.2	59	1.691	75.2	61.4	76.3	62.3
38	1.357	44.5	36.3	45.5	37.2	60	1.711	76.9	62.8	78.0	63.6
39	1.370	45.9	37.5	46.9	38.3	61	1.732	78.6	64.2	79.8	65.1
40	1.383	47.3	38.6	48.1	39.5	62	1.753	80.4	65.7	81.7	66.7
41	1.397	48.7	39.7	49.9	40.7	63	1.774	82.4	67.2	83.9	68.5
42	1.410	50.0	40.8	51.2	41.8	64	1.796	84.6	69.0	86.3	70.4
43	1.424	51.4	41.9	52.5	42.9	65	1.819	87.4	71.3	89.5	73.0
44	1.438	52.8	43.1	54.0	44.1	65.5	1.830	89.1	72.7	91.8	74.9
45	1.453	54.3	44.3	55.1	45.2	65.8	1.837	90.4	73.8	94.5	77.1
46	1.468	55.7	45.5	56.9	46.4	66	1.842	91.3	74.5	100	81.6
47	1.483	57.1	46.6	58.2	47.5	66.2	1.846	92.5	75.5	"	"
48	1.498	58.5	47.8	59.6	48.7	66.4	1.852	95.0	77.5	"	"
49	1.514	60.0	49.0	61.1	50.0	66.6	1.857	100	81.6	"	"

Some observations have been made by Wackenroder(3) on the crystallised hydrate of sulphuric acid  $2 \text{HO} + \text{SO}_3$ . The most perfect crystals are obtained from an acid containing (like rectified sulphuric acid) rather more water than the hydrate  $\text{HO} + \text{SO}_3$ ; the crystals are rhombic prisms of about  $105^\circ$  and  $75^\circ$ ; they fuse to a liquid, the sp. gr. of which at  $8^\circ$ , is 1.781, and which solidifies perfectly at  $+4^\circ$ .

(1) Ann. Ch. Phys. [3] XXVI, 123; J. Pharm. [3] XV, 115; Ann. Ch. Pharm. LXXII, 226.

(2) Compare Annual Report, for 1847 and 1848, Vol. I, 371.

(3) Arch. Pharm. [2] LVIII, 23.

**Selenium. Selenites.**—J. S. Muspratt(1) has examined various salts of selenious acid.—*Neutral selenite of potassa* was prepared by saturating carbonate of potassa with selenious acid and evaporating rapidly: it can only be obtained pure with difficulty, as traces of selenium easily separate; it is easily soluble in water, nearly insoluble in alcohol, by which it is separated from its aqueous solution in the form of an oil; it has a disagreeable taste, an alkaline reaction, and is very deliquescent. *Biselenite of potassa* forms crystals of silky lustre of the formula  $\text{KO}, \text{SeO}_2 + \text{H}_2\text{O}$ ,  $\text{SeO}_2$ ; it crystallises best (over sulphuric acid) when carbonate of potassa is saturated by selenious acid in such a manner that the liquid acquires only a slightly acid reaction; it is precipitated from its aqueous solution by alcohol, as an oily mass which soon becomes crystalline; when heated it evolves water and selenious acid, the neutral selenite remaining behind. *Quadriselenite of potassa* could not be obtained in a fit state for analysis.—*Neutral selenite of soda* could not be obtained from its aqueous solution in combination with water of crystallisation; it is precipitated by alcohol. *Biselenite of soda* forms spear-shaped crystals,  $\text{NaO}, \text{SeO}_2 + \text{H}_2\text{O}$ ,  $\text{SeO}_2 + 2 \text{H}_2\text{O}$ . A solution of this salt in selenious acid deposited by spontaneous evaporation acicular crystals of *quadriselenite of soda*,  $\text{NaO}, \text{SeO}_2 + 3 (\text{H}_2\text{O}, \text{SeO}_2) + \text{H}_2\text{O}$ , which were not deliquescent.—*Selenite of ammonia*,  $\text{NH}_4\text{O}, \text{SeO}_2$  is obtained in splendid lustrous, deliquescent crystals, by passing ammoniacal gas into an alcoholic solution of selenious acid. On addition of a drop of strong solution of ammonia to crystallised selenious acid, combination immediately ensues, attended by a considerable disengagement of heat, and sometimes by the separation of selenium.—When carbonate of magnesia is treated with selenious acid, *selenite of magnesia* remains behind, which dissolves in boiling water, and crystallises from this solution in rhombic prisms  $\text{MgO}, \text{SeO}_2 + 3 \text{H}_2\text{O}$ .—*Selenite of alumina* is obtained as an amorphous powder, having, when dried over sulphuric acid, the formula  $\text{Al}_2\text{O}_3, 3 \text{SeO}_2 + \text{H}_2\text{O}$ , by precipitating a solution of alum with a neutral selenite of an alkali.—*Selenite of sesquioxide of chromium*,  $\text{Cr}_2\text{O}_3, 3 \text{SeO}_2$ , is obtained as a green amorphous powder when sesquichloride of chromium is decomposed by selenite of ammonia.—*Selenite of sesquioxide of iron*,  $\text{Fe}_2\text{O}_3, 3 \text{SeO}_2 + 4 \text{H}_2\text{O}$ , is formed in a similar manner as a yellow precipitate.—*Selenite of protoxide of manganese*,  $\text{MnO}, \text{SeO}_2 + 2 \text{H}_2\text{O}$ , is produced by treating carbonate of manganese with selenious acid; it is a white sandy powder, insoluble in water, yielding with cold hydrochloric acid a colourless, with hot acid a pale-red solution.—*Selenite of nickel* is precipitated from solution of sulphate of nickel, by selenite of potassa, as a greenish powder of the formula  $\text{NiO}, \text{SeO}_2 + 2 \text{H}_2\text{O}$ , becoming white by desiccation.—*Selenite of zinc* is obtained in a similar manner as a

(1) Chem. Soc. Qu. J. 11, 52; Ann. Ch. Pharm. LXX, 274 (in abstr.).

Selenium.  
Selenites.

white crystalline powder,  $\text{ZnO}$ ,  $\text{SeO}_2 + 2\text{HO}$ , which parts with water when heated and fuses to a yellowish liquid. Protochloride of cadmium produces with selenite of ammonia an anhydrous and gelatinous precipitate, which becomes orange-coloured by exposure to the air, and furnishes a reddish-yellow sublimate when heated in a test-tube.—Muspratt found that the copper-salt, precipitated from a hot solution of sulphate of protoxide of copper by biselenite of ammonia, was composed according to the formula  $3 (\text{CuO}, \text{SeO}_2) + \text{HO}$ .

**Iodine.**—In a paper (which has only been published in abstract), on the state in which iodine is contained in marine plants and other natural productions, Dorvault(1) arrives at the conclusion that this element exists in them in combination with potassium. A. Völcker(2) found iodine in the ash of specimens of *Armeria maritima*, that had grown near the sea; he detected traces of fluorine in the ash of this plant obtained from any locality. Genteles(3) found iodine in the aluminous slate of Latorp in Sweden.

The presence of iodide of cyanogen in commercial iodine, referred to in our former Report (Vol. I, 289), has also been observed by Klobach(4). From 80 pounds of iodine from Hamburg, he obtained, by mixing it with mercury and subliming, besides iodide of mercury, 12 ounces of iodide of cyanogen in crystals an inch in length. Goepel(5) has investigated the spontaneous decomposition of tincture of iodine, and has found that in a tincture prepared from 1 part of iodine to 16 of alcohol (of 90 Tr.) at a gentle temperature with exclusion of light, and afterwards preserved in the cold and dark, the decomposition in a period of three months affected only 1 per cent of the iodine contained therein.

**Iodide of Potassium.**—Schönbein(6) has enumerated several substances which, when mixed with iodide of potassium, decompose the latter in the dry way with separation of iodine. Dry arsenic acid, even in the cold, liberates some iodine; at a higher temperature abundant vapours of iodine are disengaged ( $3 \text{AsO}_5 + 2 \text{KI} = 2 [\text{KO}, \text{AsO}_5] + \text{AsO}_3 + 2 \text{I}$ ); the latter is likewise effected at a higher temperature by antimonie acid. Chromic acid, even in the cold, effects the separation of iodine; this is also the case with bichromate of potassa, molybdic and tungstic acids; stannic, titanic, and uranic acids produce the same effect with the aid of heat. On projecting dry pulverised iodide of potassium into fused anhydrous phosphoric acid, a violent disengagement of iodine takes place, attended by a transient ignition; fused hydrate of phosphoric acid liberates iodine

(1) Compt. Rend. XXVIII, 66; J. Pharm. [3] XV, 209.

(2) Chem. Gaz. 1849, 409; Instit. 1849, 406.

(3) From the Reports of the Stockh. Acad. 1848, 131, in Arch. Ph. Nat. XI, 230; Chem. Gaz. 1850, 46.

(4) Arch. Pharm. [2] LX, 34.

(5) Arch. Pharm. [2] LX, 29.

(6) Pogg. Ann. LXXVIII, 513.

abundantly from iodide of potassium; this reaction is accompanied by the phenomenon of flame and the formation of a considerable quantity of hydriodic acid. Silicic and boracic acids effect a perceptible disengagement of iodine-vapours at an elevated temperature, when atmospheric air or oxygen are present. Sesquichloride of iron, sulphate of sesquioxide of iron ( $\text{Fe}_2\text{O}_3, 3 \text{ SO}_3$ ), and other salts of this oxide, as also ferricyanide of potassium and salts of the protoxide of copper separate iodine from iodide of potassium even in the cold.—The above-mentioned substances effect the corresponding decompositions with bromide of potassium but with less facility (silicic and boracic acid exhibit scarcely any action, however high the temperature). Of the metallic chlorides, those of potassium and sodium are not decomposed by any of the above agents, even at a high temperature; chlorine is, however, expelled from the chlorides of barium, strontium, calcium, or magnesium by these substances, particularly by bichromate of potassa, at an elevated temperature.

Iodide of potassium.

**Hydriodic and Hydrobromic Acids.**—For the preparation of gaseous hydriodic and hydrobromic acids, Mène(1) recommends the addition of 5 parts of iodine or bromine to 4 parts of crystallised hypophosphite of lime and one part of water; hydrobromic acid is disengaged at the ordinary temperature and hydriodic acid with the aid of a gentle heat. ( $\text{CaO}, \text{PO} + 4 \text{ HO} + 4 \text{ I} = \text{CaO}, \text{PO}_5 + 4 \text{ HI}$ ). A still better method for the preparation of these gases, according to this chemist, consists in moistening 6 parts of crystallised sulphite of soda with 1 part of water, adding 3 parts of iodine or bromine, and then applying heat ( $\text{NaO}, \text{SO}_2 + \text{HO} + \text{I} = \text{NaO}, \text{SO}_3 + \text{HI}$ ).—Gladstone(2) recommends the action of iodine or bromine upon hyposulphite of soda, moistened with a little water ( $\text{NaO}, \text{S}_2\text{O}_2 + \text{HO} + \text{Br} = \text{NaO}, \text{SO}_3 + \text{S} + \text{HBr}$ ); the application of heat is necessary in the preparation of hydriodic acid by this method.

**Chlorine.**—Laurent(3) has communicated the following experiment as a contribution towards the determination of the equivalent of chlorine, and as a reply to the question, whether it be a multiple of the equivalent of hydrogen. Two glass flasks of about equal size are placed in the two pans of a balance, one of which is loaded in addition with 5.38125 grammes in weights; the whole is then brought into a state of equilibrium by counterpoises. 4.050 grammes of the weights are then removed, and an equal weight of pure silver is put into the flask on the same pan, equal quantities of nitro-hydrochloric acid are now introduced into the two flasks and evaporated (whereby the silver in the one is converted into chloride of silver); both the flasks are then heated, until the chloride of silver in the one fuses. They

(1) Compt. Rend. XXVIII, 478; Instit. 1849, 113; J. Pr. Chem. XLVII, 126.

(2) Loc. cit. 164.

(3) Loc. cit. 153.



Chlo-  
rine.

are then placed on the balance in their respective pans; on removing the remainder of the weights (1.33125 grm.) equilibrium will be restored as before. This experiment shows that the equivalents of silver and chlorine stand to each other in the relation of 4.050 to 1.33125, *i. e.* of 108 to 35.5.

The property possessed by chlorine-water of converting chloride of lead into binoxide of lead, and chloride of manganese into the bin-oxide of that metal, under the influence of solar light, is based, according to Millon(1), upon the formation of hypochlorous acid which can only exist together with the hydrochloric acid simultaneously formed, when a large quantity of water is present. He calls attention to the similarity of the formulæ  $\text{HIO}$  and  $\text{ClO}$ ,  $\text{HS}$  and  $\text{ClS}$ ; the latter compound he views as hydrosulphuric acid, in which  $\text{H}$  is replaced by  $\text{Cl}$ , and he considers that this view explains why the compound of chlorine with the largest amount of sulphur, could only contain equal equivalents of the two elements.

**Hydrochloric Acid.**—According to N. W. Fischer(2), chlorine is liberated from an aqueous solution of hydrochloric acid, when the latter is exposed in a closed bottle for a lengthened period to the influence of the sun's rays; in the presence of a small piece of gold-leaf the formation of solution of gold is observed, under these circumstances, after the lapse of a few hours.

**Chlorate of Soda.**—Winckler(3) has communicated the results of his experience in the manufacture of chlorate of soda. He recommends its preparation by the decomposition of acid tartrate of soda by chlorate of potassa; the directions given by him do not differ materially from those previously given by other authors, more particularly by Wittstein.

**Fluorine.**—Louyet(4) has instituted some experiments on the equivalent of fluorine. Berzelius had obtained, as a mean of several experiments, from 100 pure (artificially prepared) fluoride of calcium 175 sulphate of lime; Louyet obtained, as mean, from 100 pure fluorspar, or artificially prepared fluoride of calcium, 173.53 sulphate of lime, which would lead to the number 19.2 as the equivalent of fluorine. Louyet conjectured that fluoride of calcium might perhaps not be perfectly decomposed by sulphuric acid. He prepared pure fluoride of sodium, and decomposed this by sulphuric acid; 1 grm. of fluoride of sodium gave 1.686; 1.683 and 1.685 of sulphate of soda, which is more than should be obtained according to the equivalent given above (1.680 being the theoretical quantity). Louyet therefore instituted some experiments with perfectly transparent

(1) Compt. Rend. XXVIII, 42; Instit. 1849, 29.

(2) J. Pr. Chem. XLVIII, 70.

(3) Jahrb. Pr. Pharm. XVIII, 35.

(4) Ann. Ch. Phys. [3] XXV, 291; J. Pr. Chem. XLVII, 104; Ann Ch. Pharm. LXX, 234 (in abstr.); Instit. 1849, 2.

and pure fluorspar, on which he allowed sulphuric acid to act at first in the cold, until perfect solution was effected, after this he evaporated it to dryness and heated it to redness; he thus obtained from 1 of fluorspar 1.742, 1.744, 1.745, 1.744, 1.7435, 1.7435, or a mean of 1.7436 of sulphate of lime; from these experiments he determined the equivalent of fluorine as = 19, the theoretical amount of sulphate of lime corresponding to which is 1.74358. From 1 grm. of fluoride of barium he obtained (by solution in nitric acid and precipitation by sulphuric acid) 1.332, 1.331, 1.330 sulphate of baryta ( $F=19$  requires 1.3309). 1 grm. of artificially prepared fluoride of calcium gave from 1.741 to 1.743 sulphate of lime. 5 grms. of fluoride of lead gave 6.179, 6.178, 6.178 of sulphate of lead ( $F=19$  requiring 6.1828); Louyet does not consider the latter experiments as decisive, as the equivalent of lead itself is not very accurately known, and the fluoride of lead employed might perhaps have still contained some hydrofluoric acid. He maintains that the equivalent of fluorine must be expressed by 19, a simple multiple of the equivalent of hydrogen.

**Nitrogen.**—For the preparation of pure nitrogen, Corenwinder(1) recommends heating a mixture of nitrite of potassa and chloride of ammonium, instead of the nitrite of ammonia which is difficult to obtain. The vapours, formed by the action of 10 parts of nitric acid upon 1 of starch, are passed into an aqueous solution of caustic potassa of 1.38 sp. gr., until it has an acid reaction, caustic potassa is then added until the reaction is distinctly alkaline; for the preparation of nitrogen, 3 volumes of concentrated solution of chloride of ammonium are added to 1 volume of the above liquid, which may be preserved without undergoing decomposition. The mixture is gently heated, and the gas, which is disengaged with regularity, is passed through dilute sulphuric acid, to remove a small admixture of ammonia.

**Protoxide of Nitrogen.**—Despretz(2) observed that liquid protoxide of nitrogen assumed the spheroidal condition as well in a platinum dish at the ordinary temperature as in one at a red-heat; when exposed in a silver capsule, upon a hot stone, under the bell of the air-pump, liquid protoxide of nitrogen was soon converted into a snow-like mass.

**Nitric Acid.**—Deville(3) has obtained anhydrous nitric acid, by allowing perfectly dry chlorine to act upon nitrate of silver. He allows the chlorine, retained in a glass gasometer by means of sul-

(1) Ann. Ch. Phys. [3] XXVI, 296; J. Pharm. [3] XVI, 197; Ann. Ch. Pharm. LXXII, 225; J. Pr. Chem. XLVII, 464; Phil. Mag. [3] XXXV, 317; Chem. Gaz. 1849, 347.

(2) Compt. Rend. XXVIII, 143; Instit. 1849, 67; J. Pharm. [3] XV, 177; J. Pr. Chem. XLVII, 466.

(3) Compt. Rend. XXVIII, 257; Instit. 1849, 57; J. Pharm. [3] XV, 207; J. Chim. Med. [3] V, 242; J. Pr. Chem. XLVII, 185; more in detail Ann. Ch. Phys. [3] XXVIII, 241; Ann. Ch. Pharm. LXXIV, 96.

Nitric  
acid.

phuric acid, to pass exceedingly slowly over chloride of calcium, then over sulphuric acid, and finally over well-dried nitrate of silver, which is previously heated to  $95^{\circ}$ , and then for a length of time to  $58-66^{\circ}$ . The products of decomposition pass into a U-shaped tube, the lower part of which is cooled down to  $-21^{\circ}$ , in which are deposited, besides a very volatile liquid (nitrous acid?), crystals of nitric acid, while oxygen escapes. The connections of the apparatus, which are exposed to the action of nitric acid, cannot be made by means of caoutchouc tubes, but must be effected by fusion of the glass before the blow-pipe. Anhydrous nitric acid,  $\text{NO}_5$ , crystallises in colourless rhombic prisms of about  $60^{\circ}$  and  $120^{\circ}$ , and in six-sided columns derived from this form; it fuses at from  $29^{\circ}$  to  $30^{\circ}$ , and boils at from  $45^{\circ}$  to  $50^{\circ}$ , decomposition ensuing at a temperature approaching the boiling-point; it evolves much heat with water, in which it dissolves without colouration or evolution of gas, forming hydrated nitric acid. Its analysis agreed with the formula  $\text{NO}_5$ .

Dumas(1) has observed that the crystals, when sealed up in a glass tube and left to themselves, fuse, and that in endeavouring to make the fused mass crystallise again, by means of a freezing mixture, an explosion ensued, and the tube was shattered to pieces.

**Atmospheric Air.**—H. and A. Schlaginweit(2) have made some investigations on the amount of carbonic acid contained in the air in the Eastern Alps. They found 10000 volumes of air contained between 3.2 and 5.8 volumes of carbonic acid; they observed a progressive increase in the amount, up to an altitude of 3336 meters, but they believe that they approached there to the maximum-limit. They determined the carbonic acid by passing the dried air (from 3331 to 5905 cubic centimeters) over potassa, and determining subsequently the increase in weight of the latter. The increase produced by the quantities of air employed was too small (3 to 6 milligr.) to admit of deducing definite conclusions respecting the variations of the amount of carbonic acid in the atmosphere(3).

Fresenius(4) has examined the amount of ammonia contained in atmospheric air. He passed air through dilute hydrochloric acid for a period of 40 days (in August and September, 1848), by means of one aspirator during the day-time, and another during the night; after the completion of the experiment, the amount of ammonia was determined in the hydrochloric acid liquid, by means of bichloride of

(1) *Compt. Rend.* XXVIII, 323; *Instit.* 1849, 99.

(2) *Pogg. Ann.* LXXXVI, 442; *Arch. Pharm.* [2] LIX, 291.

(3) *Compare Ann. Ch. Pharm.* LXXII, 216.

(4) *J. Pr. Chem.* XLVI, 100; *Ann. Ch. Phys.* [3] XXVI, 208; *J. Pharm.* [3] XV, 311; *Ann. Ch. Pharm.* LXXII, 218 (in the latter reference attention is called to the circumstance that finely divided chloride of ammonium, suspended in a large volume of air, may be easily carried through a liquid).

platinum, as platinum, and a perfectly similar determination was made with an equal quantity of hydrochloric acid, through which no air had been passed.

Atmo-  
spheric  
air.

345250 cubic centimeters of day-air . . .	gave 0.00206 grm. of platinum.
344250 " " night-air . . .	" 0.00223 "
Hydrochloric acid and bichloride of platinum alone "	0.00182 "

From these experiments, Fresenius calculates the amount of ammonia, yielded by air alone, at 0.098 parts by weight to 1000000 parts of air in the day, and at 0.169 parts by weight at night. Gräger(1) found 0.333 parts, and Kemp(2) even as much as 3.68.

**Ammonia.**—Mohr(3) has communicated some experiments on the preparation of solution of ammonia, particularly with regard to the amount of ammonia that is expelled from chloride of ammonium by various quantities of caustic lime, the distillation being continued until the mixture becomes dry, without being heated to redness. The results of his experiments were, that 5 parts of caustic lime to 4 parts of chloride of ammonium is the smallest proportion by which the perfect decomposition of the chloride of ammonium can be effected; in employing equal quantities of lime and chloride of ammonium, 10 per cent of the latter remain undecomposed, and 20 per cent if one-half the quantity of lime be employed; the smallest possible quantity of water necessary for the operation must be employed, and the quantity used should be equal to the weight of the chloride of ammonium.

**Sulphide of Nitrogen.**—In a paper on sulphide of nitrogen and the inorganic lepnamides (compounds which may be considered as acid + ammonia—water), Laurent(4) denies the existence of sulphide of nitrogen; he states that the substance designated by this name is a mixture containing hydrogen and about 10 per cent of oxygen, and from which sulphide of carbon extracts a yellow crystalline body,  $S_2HN$ , which yields, by the assumption of 3 atoms of water, hyposulphite of ammonia. He has, moreover, communicated his views respecting the products of the action of ammonia upon chlorides, anhydrous sulphuric acid, &c. His conjectures, that many of these products which have hitherto been considered as true compounds are mixtures, and his statement respecting the substances of which they are likely to consist, cannot well be given in abstract, we must therefore refer to the original paper.

**Compounds containing Phosphorus and Nitrogen.**—Gladstone(5) has examined several compounds containing phosphorus and nitrogen.

(1) Arch. Pharm. [2] XLIV, 35.

(2) Compare the Annual Report for 1847 and 1848, I, 299.

(3) Arch. Pharm. [2] LVIII, 129.

(4) Compt. Rend. XXIX, 557.

(5) Chem. Soc. Qu. J. II, 121.

Com-  
pounds  
containing  
phospho-  
rus and  
nitrogen.

On saturating pentachloride of phosphorus ( $\text{PCl}_5$ ) with dry ammoniacal gas, a white powder is formed, containing chloride of ammonium, chlorophosphide of nitrogen, and a peculiar substance which, when washed for some time with hot water, splits up into chloride of ammonium, and a white, insoluble powder, free from chlorine. Wöhler and Liebig considered the latter as  $\text{PH}_2\text{N}_2\text{O}_2$ , Gerhardt ascribed to it the formula  $\text{PH}_3\text{N}_2\text{O}_2$ , and called it *phosphamide*(1). Gladstone found that the best method of preparing this substance is to free the white body obtained from pentachloride of phosphorus by ammoniacal gas, from chlorophosphide of nitrogen by exhaustion with ether, or boiling with water, when the chlorophosphide of nitrogen is volatilised with the aqueous vapour, and to maintain the residue in ebullition with water for five or six hours, until a washed and dried specimen on heating ceases to give a sublimate of chloride of ammonium. The substance thus prepared is insoluble in alcohol, oil of turpentine, and water; when boiled with the latter it is decomposed slowly into phosphoric acid and ammonia, and more rapidly in the presence of a caustic alkali; it undergoes the same decomposition when heated with sulphuric acid, the solution becoming dark-coloured. When fused with caustic potassa, it yields ammonia and phosphate of potassa; when heated alone, ammonia is evolved and a compound formed which will be presently discussed; when heated in the moist state, ammonia is disengaged, and metaphosphoric acid remains behind; the latter decomposition, however, is never perfect, as a dark-coloured insoluble substance is always left behind. It is not acted upon by boiling nitric acid, or a boiling mixture of nitric and sulphuric acids. Gladstone found that the substance, prepared as above, and dried at  $100^\circ$ , contained from 30.4 to 32.0 per cent of phosphorus, 3.3 to 3.6 of hydrogen, 27.3 to 27.7 of nitrogen, which numbers correspond most nearly to the formula  $\text{P}_2\text{H}_6\text{N}_4\text{O}_9$  (theory 32.3 per cent P; 3.0 H; 28.3 N; 36.4 O); he considers however the formula  $\text{PH}_3\text{N}_2\text{O}_2$  as more probable. According to the latter, the calculated numbers are 31.1 per cent P; 2.9 H; 27.2 N; 38.8 O.

On heating this substance, ammonia is disengaged, and a compound remains behind, which Gerhardt termed *biphosphamide*, and which he considered as composed according to the formula  $\text{PNO}_2$ . The decomposition is the same if the substance be heated rapidly in atmospheric air, oxygen, hydrogen, carbonic acid or ammonia, to a faint red-heat; it is most advantageous, however, to heat it with the exclusion of oxygen. A greyish-white powder remains, amounting, in various experiments, to 8.34, 83.7, 83.6, 82.7 per cent of the substance employed, and in which Gladstone found 38.8 per cent of phosphorus and 16.3 per cent. of nitrogen; the formula  $\text{PNO}_2$  requires

(1) Compare the Annual Report for 1847 and 1848, I, 451.

Com-  
pounds  
containing  
phospho-  
rus and  
nitrogen.

37.2 per cent P, 16.3 N and 46.5 O, the formula  $P_2N_2O_9$ , 39.0 P, 17.1 N and 43.9 O. In the conversion of  $PH_3N_2O_5$  into  $PNO_5$ , the residue should amount to 83.5 per cent, in the conversion of  $P_2H_6N_4O_9$  into  $P_2N_2O_9$ , to 82.9 per cent of the substance employed. Gladstone considers the formula  $PNO_5$  as the more probable. This compound is insoluble in the ordinary solvents; it remains unaltered by boiling with caustic potassa; by fusion with hydrate of potassa, ammonia is disengaged, and phosphate of potassa formed. When the substance is boiled with sulphuric acid, decomposition ensues, the liquid is blackened, and some sulphurous acid disengaged. It is not decomposed by boiling nitric acid, but by fusion with nitre; it fuses at a full red-heat, and solidifies on cooling to a black vitreous mass; when heated in the moist state, it yields phosphoric acid and ammonia, the decomposition is, however, not perfect. It is not changed by heating in chlorine, or with iodine or sulphur; when heated in pure hydro-sulphuric acid, it assumes a dark semi-fused and tough appearance. When heated in hydrogen, it evolves ammonia, and afterwards white vapours of phosphoric or phosphorous acid, together with spontaneously inflammable phosphoretted hydrogen, while a red sublimate (apparently impure oxide of phosphorus, and frequently some water are formed. In one experiment no sublimate, nor phosphoretted hydrogen, but much phosphoric acid and water were formed. A dark brown residue was obtained in this experiment, which withstood the action of hydrogen.

If the compound termed phosphamide (comp. p. 176) is heated very slowly with free access of atmospheric air, a disengagement of ammonia commences at about  $150^\circ$ , accompanied by an increase in the weight of the substance; both phenomena continue for some time between  $150^\circ$  and  $250^\circ$ ; a dark coloured substance is formed, which is decomposed by water into a soluble and an insoluble portion; the latter is identical with the substance just above described. In one experiment, in which but little of the latter compound was formed, the increase of weight, produced by the absorption of oxygen, notwithstanding the disengagement of ammonia, amounted to 22.8 per cent. The solution of the portion soluble in water contained only a trace of free acid, and yielded on evaporation a crystalline mass, consisting principally of phosphate of ammonia.

In conclusion, Gladstone discusses the remarks made by Gerhardt respecting the substance which H. Rose named phosphide of nitrogen, and considered as composed according to the formula  $N_2P$ ; he finds no sufficient reason for doubting the correctness of the latter formula.

**Magnesium.**—Chodnew(1) has instituted some researches on nitrate of magnesia, and confirmed, in the most important points,

(1) Petersb. Acad. Bull. VIII, 137; Ann. Ch. Pharm. LXXI, 241; J. Pr. Chem. XLIX, 107.

Magnesium.

the earlier statements of Graham, which were disputed by Einbrodt(1).  $\text{MgO}, \text{NO}_5 + 6 \text{HO}$  crystallises, according to Chodnew, in rhombic prisms the angles of which measure  $122^\circ 30'$  and  $57^\circ 30'$ ; it is very deliquescent, dissolves in considerable quantity in alcohol of 0.795 sp. gr. at  $20^\circ$ , more easily on the application of heat; loses by protracted exposure over sulphuric acid, 4 equivalents of water and 5 at from  $120^\circ$  to  $245^\circ$ , and parts with the last atom only at a higher temperature, when some nitric acid is simultaneously liberated and decomposed. The residue then contains, besides anhydrous nitrate of magnesia, an insoluble basic salt,  $3 \text{MgO}, \text{NO}_5$ . Chodnew did not succeed in preparing a double-salt of nitrate of magnesia and nitrate of ammonia.

**Lanthanum. Didymium.**—Marignac, in continuation of his former experiments(2) on the equivalent of cerium, has also endeavoured to determine the atomic weights of the metals associated with it, namely, of lanthanum and didymium(3). Oxide of cerium may be obtained pure, by heating the mixture of the three oxides first with diluted, and afterwards with concentrated nitric acid which extracts the last traces of lanthanum and didymium. The oxides of these two metals may be likewise purified from cerium, by evaporating the solution obtained by dilute nitric acid, igniting the residuc, and treating this with nitric acid, diluted with at least 200 times its weight of water. The separation of the oxides of lanthanum and didymium is far more difficult. Marignac first had recourse to Mosander's method, which is based upon the fact, that a solution of the sulphates of both oxides saturated at from  $5^\circ$  to  $6^\circ$ , when heated to about  $30^\circ$ , deposits the sulphate of lanthanum, while the sulphate of didymium is almost entirely retained in solution at this temperature. The sulphate of lanthanum may be obtained colourless by repeatedly being subjected to this process; the sulphate of didymium, freed as much as possible by this method from the lanthanum-salt, was still farther purified; the darker coloured crystals were collected and re-crystallised, and this process was frequently repeated.(4) Marignac

(1) Comp. Annual Report for 1847 and 1848, I, 303.

(2) Comp. Annual Report for 1847 and 1848, I, 303.

(3) Arch. Ph. Nat. XI, 21; Ann. Ch. Pharm. LXXI, 306; Chem. Gaz. 1849, 329; together with the investigation of lanthanum, Ann. Ch. Phys. [3] XXVII, 209; J. Pr. Chem. XLVIII, 406; Laur. and Gerh. C. R. 1849, 437, (in abstr.).

(4) H. Watts, who has published a synopsis of the various methods for the separation of cerium, lanthanum and didymium, states that by slowly crystallising an acid solution containing little sulphate of lanthanum, and more sulphate of didymium, picking out the rose-coloured crystals (containing didymium), and the violet ones (containing lanthanum and didymium), adding the solution of the latter to the mother-liquor and repeating the process, the whole of the didymium may be finally separated by crystallisation, and a solution of pure sulphate of lanthanum thus obtained. In addition, he briefly states that the oxides of lanthanum and didymium may be perfectly separated from oxide of cerium by boiling the mixture of the oxides (obtained from the nitric acid solution by evaporating to dryness), with a solution of chloride of ammonium; the portion that is first dissolved contains but little didymium. (Chem. Soc. Qu. J. II, 140.)

was not successful in detecting other methods for the separation of these substances. (When a strongly ignited mixture of the oxides of lanthanum and cerium is allowed to remain for a long time at the ordinary temperature, in contact with much water, containing an insufficient amount of nitric acid for their perfect solution, the oxide of lanthanum will be dissolved by preference; a solution of the mixed oxalates of lanthanum and didymium in dilute hydrochloric acid deposits the didymium-salt first on evaporation; both of these methods afford, however, very incomplete means of separation.)—The sulphate of lanthanum forms small colourless crystals, apparently hexagonal prisms, terminated by hexagonal pyramids, which are, however, the combination  $\infty P . \infty \bar{P} \infty . P . m \bar{P} \infty$  of the rhombic system ( $\infty P : \infty \bar{P} = 119^\circ 30'$ ; at the termination the two inclinations  $P : P = 142^\circ$ , the four inclinations  $P : m \bar{P} \infty = 142^\circ 20'$ ); this salt contains 3 atoms of water. — The sulphate of didymium crystallises with facility in lustrous, monoclinometric crystals of a dark rose-red colour ( $0 P : \infty P \infty = 118^\circ 8'$ ;  $+ P : + P = 54^\circ 12'$ ;  $- P : - P = 78^\circ 48'$ ;  $+ P : - P = 143^\circ 49'$ ;  $0 P : + P = 110^\circ 3'$ ;  $0 P : - P = 125^\circ 20'$ ;  $0 P : + P \infty = 138^\circ 49'$ ;  $0 P : - P \infty = 155^\circ 40'$ ; twin crystals; planes of combination parallel to  $\infty P \infty$ ; cleavage parallel to  $0 P$ ); it also crystallises with 3 atoms of water.—By determining the quantity of chloride of barium requisite for the decomposition of a weighed amount of the sulphate, Marignac found for the equivalent of lanthanum as a mean 47.04. Rammelsberg had found it to be = 44.7, Mosander = 46.4, and Hermann, disregarding an admixture of didymium, = 48. The equivalent of didymium is found by Marignac to be 49.6; he considers this number as a lower limit, because an admixture of lanthanum would tend to lower the equivalent of didymium.

**Aluminium.**—According to J. S. Muspratt(1), the precipitate produced by carbonate of ammonia in a solution of alum contains carbonic acid and has the formula  $3 Al_2 O_3, 2 CO_2 + 16 HO$ .

The observation that the solution of cubic alum deposits, upon heating, basic sulphate of alumina, and that the filtrate then yields, on crystallisation, only octahedral alum, has led Persoz(2) to the conclusion that cubic and octahedral alum are not identical in composition, but that the former contains more alumina.

According to Laurent(3), the crystalline salt, formed upon addition of alum to hot concentrated sulphuric acid, contains no alkali, but is composed according to the formula  $SO_4 al \frac{3}{4} H \frac{1}{4}$ , al representing the equivalent of aluminium, in accordance with the assumption of alumina as al O.

(1) Chem. Soc. Qu. J. II, 216; Ann. Ch. Pharm. LXXII, 120; Laur. and Gerh. C. R. 1849, 242.

(2) Loc. cit. 191.

(3) Loc. cit. 153.



Tita-  
nium.

**Titanium.**—The copper-coloured cubes, frequently formed in smelting furnaces, which have hitherto been generally regarded as metallic titanium, are, according to Wöhler's(1) investigation, a combination of cyanide of titanium with nitride of titanium,  $\text{TiC}_3\text{N} + 3\text{Ti}_3\text{N}$ . On heating them in dry chlorine, besides liquid bichloride of titanium, a very volatile body is formed, which sublimes in small sulphur-yellow crystals, and is a combination of bichloride of titanium with chloride of cyanogen. On heating the powdered cubes to redness in a porcelain tube in a current of aqueous vapour, and passing the resulting hydrogen through cold water, the latter absorbs ammonia and hydrocyanic acid; if the cubes are employed for this experiment in an undivided state, the resulting titanous acid retains the form of rounded cubes which are, however, aggregations of small crystals of the form of anatase. The cubes which were examined contained about 1 per cent of graphite, which is evidently an unimportant admixture. When mixed in the form of powder with the oxides of copper, lead, or mercury, and heated, they burn with violent deflagration, and the oxides are reduced; when mixed in the form of powder with chlorate of potassa, and heated, they exhibit the same phenomenon. Wöhler considers it certain that the formation of these cubes has some connection with the production of cyanide of potassium in smelting furnaces, a fact that has been frequently observed. A mixture of anhydrous ferrocyanide of potassium and titanous acid maintained, in a closed crucible, for more than an hour at the fusing temperature of nickel, yielded a brown, unfused, porous mass, from which only traces of cyanide of potassium were extracted by water, and which, when magnified 300 times, was found to consist of metallic iron and a network of copper-coloured, highly lustrous, fine short prisms. When the mass was treated with concentrated hydrochloric acid, a brown powder remained behind, which was a mixture of copper-coloured needles and carbon, and comported itself very similarly to the powdered cubes. Wöhler confirmed Zincken's statement, that the cubes are volatile at a very high temperature; when maintained for an hour at the temperature of fusing nickel, they exhibited feeble signs of volatility.

The copper-coloured substance, considered to be pure titanium, which was first obtained by H. Rose from the ammonio-chloride of titanium, and which can be prepared, according to Liebig's method, by heating this compound in ammoniacal gas, is nitride of titanium  $\text{Ti}_3\text{N}_2$ ; its colour is more copper-red, while that of the above-named cubes has a strong tint of yellow. When heated with hydrate of

(1) Ann. Ch. Pharm. LXXIII, 34; Ann. Ch. Phys. [3] XXIX, 166; Berl. Acad. Ber. 1849, 244, (in abstr.); Pogg. Ann. LXXVIII, 401; Chem. Soc. Qu. J. II, 352; Chem. Gaz. 1850, 73; Ann. Ch. Phys. [3] XXVIII, 382; Compt. Rend., XXIX, 505; Instit. 1849, 353.

potassa, or exposed to a red-heat in aqueous vapour, it disengages ammonia abundantly; and when heated in chlorine it burns, forming chloride of titanium, but it does not yield when exposed in that gas, even in intimate admixture with carbon, any crystals of cyano-chloride of titanium. There are, besides the above, two other combinations of nitrogen with titanium; they all exhibit, like the cubes, the peculiar phenomenon of undergoing violent combustion when heated to redness, in the pulverised state, together with easily reducible metallic oxides. Nitride of titanium, of the formula  $TiN$ , is produced by exposing titanous acid at a high red-heat to a current of dry ammoniacal gas, and allowing it to cool therein; it is a dark-violet powder with a copper-coloured tint, like the powder of sublimed indigo.—The nitride of titanium  $Ti_3N_2$  is formed by submitting the compound  $Ti_3N_2$  to a high red-heat in a current of dry hydrogen and allowing it to cool therein; a portion of the nitrogen goes off as ammonia even below a red-heat; if the copper-coloured nitride of titanium is employed in lustrous scales, the new compound is obtained in beautiful brass-yellow, almost golden-coloured, laminae of a highly metallic lustre; when in the form of powder it is bronze-coloured and of metallic lustre. The same compound is perhaps produced by heating titanous acid to redness in a current of cyanogen gas or hydrocyanic acid vapour; in both cases a substance of metallic lustre is obtained in intimate admixture with charcoal.

Wöhler obtained pure metallic titanium according to the method previously employed by Berzelius, by heating titano-fluoride of potassium with potassium; the cooled mass was washed with a large quantity of lukewarm water and dried. Metallic titanium is a dark grey amorphous powder which, when magnified 100 times is found to consist of iron-coloured concretions of metallic lustre; it does not become copper-coloured even by pressure. When heated in air—for instance, when thrown into a flame—it burns with brilliancy; it ignites instantaneously, when heated in oxygen gas, or when exposed to a high temperature with minium or protoxide of copper. Its combustion in chlorine-gas is just as brilliant; it is not however acted upon by the latter gas at the common temperature. It decomposes water at  $100^\circ$ ; when it is heated with hydrochloric acid, a lively evolution of hydrogen ensues, and a colourless solution is obtained containing probably  $TiCl$ .

The following is the method given by Wöhler(1) for the preparation of pure titanous acid, free from iron. Very finely divided rutile is fused with twice its weight of carbonate of potassa, in a platinum crucible, placed inside a hessian crucible; the powdered mass is

(1) Nachr. d. Gesellsch. d. Wissensch. zu Göttingen, Dec. 1849, 169; .Instit. 1850, 46; Ann. Ch. Phys. [3] XXIX, 185.

Tita-  
nium.

dissolved, in a platinum dish, in dilute hydrofluoric acid, when titanio-fluoride of potassium soon begins to separate; the solution is heated to ebullition, with the addition of more water, if necessary, until the salt is redissolved, it is then filtered while boiling hot, in which process glass vessels may be employed, if the presence of an excess of hydrofluoric acid has been avoided. The salt that separates upon cooling is filtered off, washed a few times with cold water, pressed between bibulous paper, and purified by re-crystallisation from boiling water; when dried, it forms a lamellar mass, of nacreous lustre, similar to cholesterin. From its hot aqueous solution, snow-like titanate of ammonia is precipitated by ammonia, which is easily soluble in hydrochloric acid, and becomes incandescent by ignition, being converted into pure titanio acid. Titanio-fluoride of potassium exhibits the peculiarity of not being immediately precipitated from its cold aqueous solution by ammonia, while it is perfectly precipitated by the aid of heat. From the mother-liquor, obtained in the preparation of the above salt, dilute ammonia, when not added in excess, precipitates immediately the whole of the sesquioxide of iron, together with only a very small quantity of titanio acid; the liquid, filtered immediately—as otherwise the titanio acid would separate after a short time, even at the common temperature—is then heated to ebullition, when the whole of the titanio acid will be precipitated as the pure ammonia-salt.—This method for the preparation of pure titanio acid, is also applicable for titaniferous iron. The mass formed by fusion with carbonate of potassa is dissolved in dilute hydrofluoric acid which leaves the greater portion of iron behind, as sesquioxide. When the principal amount of titanio-fluoride of potassium has crystallised out, and is purified by re-crystallisation, the mother-liquors containing iron are mixed with chlorine-water or a hypochlorite, to convert the iron into the higher oxide, and then treated as above. Wöhler considers it probable that a method for the quantitative analysis of titaniferous iron ores may be founded upon the above process.

Also Demoly(1) has instituted researches upon titanium and its compounds. He endeavoured to prepare pure bichloride of titanium by passing dry chlorine over a mixture of equal weights of powdered rutile and charcoal, condensing the vapours that are formed, by means of a succession of receivers, purifying the more volatile distillate from sesquichloride of iron, an excess of chlorine and terchloride of silicium, by repeated rectification over mercury and potassium, passing ammonia-gas into the rectified liquid, decomposing the compound of bichloride of titanium and ammonia, that separates, by heating it in an atmosphere of ammonia, and treating the resulting body with

dry chlorine. 100 parts of the bichloride of titanium thus prepared, boiling at  $135^{\circ}$ , gave 38.4; 34.4; 34.8 of titanous acid, and 288.5; 289.8; 289.2 of chloride of silver, from which determinations Demoly has deduced the number 28 as the equivalent of titanium.—Demoly distinguishes two modifications of titanous acid: true titanous acid  $\text{TiO}_2$  and metatitanous acid  $\text{Ti}_3\text{O}_6$ . The former is obtained by precipitation of its solution in mineral acids, as a gelatinous precipitate, soluble in acids; when desiccated in dry air, until it ceases to lose in weight, it contains 26 per cent of water ( $3 \text{ TiO}_2 + 5 \text{ HO}$ ); when dried *in vacuo*, or at  $140^{\circ}$ , it contains only 7 per cent of water (according to Demoly  $\text{Ti}_3\text{O}_6 + 2 \text{ HO}$ ), and is then insoluble in acids, and similar in every respect to metatitanous acid. Titanous acid, when heated, passes over into metatitanous acid; in this conversion the substance becomes incandescent. The soluble titanates crystallise with facility; they are precipitated from their solutions by alcohol and by the salts of potassa, soda, or ammonia. Titanate of potassa, obtained by boiling gelatinous titanous acid with an excess of potassa, or by igniting metatitanates with an excess of potassa, crystallises with facility in colourless prisms of the formula  $\text{KO}, \text{TiO}_2 + 4 \text{ HO}$ ; it is very soluble, attracts moisture rapidly from the air, and has a strong alkaline reaction. Titanate of soda, obtained in the same manner, and possessing similar properties, is a white salt of the formula  $\text{NaO}, \text{TiO}_2 + 4 \text{ HO}$ .—Metatitanous acid separates in small lustrous laminæ, on saturating anhydrous bichloride of titanium with carbonate of baryta, adding at once a large quantity of water (so as to produce a sudden increase of temperature), and then heating to ebullition; it is obtained in the amorphous state by heating common titanous acid, or it is precipitated, by boiling, from its solution in sulphuric acid; it is insoluble in acids, with the exception of concentrated sulphuric acid, and exhibits no incandescence when heated. The acid, precipitated by boiling from the solution in sulphuric acid, and dried at  $140^{\circ}$ , or in a dry vacuum, has the formula  $\text{Ti}_3\text{O}_6 + 2 \text{ HO}$  (with 12 per cent of water). The metatitanates do not crystallise, and are insoluble. A potassa-salt  $\text{KO}, \text{Ti}_3\text{O}_6 + 2 \text{ HO}$  is obtained by precipitating the hydrochloric acid solution of titanous acid by carbonate of potassa; it is converted, by the action of concentrated hydrochloric acid, into an acid salt  $\text{KO}, 2 \text{ Ti}_3\text{O}_6 + 2 \text{ HO}$ . Baryta and soda form different salts in a similar manner.—Bichloride of titanium is gradually converted, by exposure to moist air, into a gelatinous mass, from which, by solution in water and proper evaporation, a crystalline substance of the formula  $\text{TiCl}_2 + 5 \text{ HO}$  may be obtained, which rapidly attracts moisture from the air, and becomes, by exposure *in vacuo* over sulphuric acid,  $\text{TiCl}_2 + 2 \text{ HO}$ .—In conclusion, Demoly mentions a combination of bichloride of titanium with ether,  $\text{TiCl}_2 + 2 \text{ C}_4\text{H}_5\text{O}$ , which is crystalline, easily soluble in an excess of ether and is decomposed by water; and lastly, a crystalline combination of the bichloride with alcohol

Tung-  
sten.  
Tungstic  
acid.

$\text{TiCl}_2 + 2 \text{C}_4\text{H}_6\text{O}_2$ , which is very deliquescent, and likewise decomposed by water.

**Tungsten. Tungstic Acid.**—Laurent(1) has endeavoured to complete his former statements(2) on tungstic acid by pointing out the characters of distinction of the modification termed by him *paratungstic acid*, and giving a synoptical view of the formulæ of the salts of this acid. The properties that distinguish paratungstic from tungstic acid are these: Its soluble salts give no precipitate on addition of very small quantities of nitric acid or very dilute hydrochloric acid; the insoluble paratungstates of magnesia, protoxide of zinc, copper, and other oxides, dissolve in a small quantity of water when a few drops of dilute nitric acid are added; the addition of an excess of ammonia does not convert paratungstates of potassa or soda into tungstates, on the contrary, a salt is always formed of the composition of  $\text{W}_4\text{O}_{12}$ ,  $\text{R}_3\text{H}_3\text{O}_2$ ; nitrate of magnesia, or zinc, dissolved in ammonia, give precipitates with paratungstates and none with tungstates; ammoniacal nitrate of silver yields with paratungstates a crystalline precipitate, whilst it produces no turbidity in tungstates; paratungstic acid has the property of forming basic salts which restore the blue colour to reddened litmus, and the composition of which may nevertheless be expressed by the formula  $\text{RO}, \text{WO}_3 + x\text{WO}_3$ .

**Chromium.**—It had been stated by Mitscherlich(3) that anhydrous bichromate of potassa was obtained crystallised, as a deep red-coloured salt, by mixing bichromate of potassa with nitric acid. Bothe(4) has observed, that upon the cooling of a solution of bichromate of potassa in ordinary nitric acid, prepared at  $60^\circ$ , two salts crystallise out, which may be easily separated by mechanical means; terchromate of potassa appears in perfectly formed deep-red prisms of pearly lustre, which may be purified by recrystallisation, but do not again form such well-defined crystals as were obtained in the first crystallisation from the nitric acid solution. Bothe confirms the formula  $\text{KO}, 3 \text{CrO}_3$  for this salt. The crystals have the sp. gr. 3.613, blacken gradually on exposure to the air, and fusc at from  $145^\circ$  to  $150^\circ$ . According to Naumann's measurements, the crystals are combinations of the monoclinometric system,  $\infty \text{P} . (\infty \text{P} \infty) . (2 \text{P} \infty) . + \text{P} . (\infty \text{P} 2) . (\text{P} \infty)$ ; principal axis: clinodiagonal: orthodiagonal =  $0.985 : 1 : 2.370$ ; angle of the two first =  $79^\circ$ ; in the clinodiagonal principal section  $\infty \text{P} : \infty \text{P} = 135^\circ 0'$ ,  $(2 \text{P} \infty) : (2 \text{P} \infty) = 101^\circ 30'$ ,  $+ \text{P} : + \text{P} = 144^\circ 10'$ .

**Chromate of Copper-Potassa.**—According to Knop, jun.(5), the chromate of copper-potassa,  $\text{KO}, \text{CrO}_3 + 3 \text{CuO}, 2 \text{CrO}_3 + 3 \text{HO}$  or,

(1) Compt. Rend. XXIX, 157; Instit. 1849, 266; J. Pr. Chem. XLVIII, 232.

(2) Comp. Annual Report for 1847 and 1848, I, 310.

(3) Lehrbuch der Chemie, II, 4 edition, 759.

(4) J. Pr. Chem. XLVI, 184.

(5) Ann. Ch. Pharm. LXX, 52.

perhaps more correctly,  $\text{KO}, \text{CrO}_3 + 2(\text{CuO}, \text{CrO}_3) + \text{CuO}, \text{HO} + 2 \text{HO}$ , is formed by pouring a solution of bichromate of potassa over freshly precipitated hydrate of protoxide of copper. It is a pure bright-yellow powder, glistening in the sunlight, and consisting of microscopic, translucent, six-sided tables. It is likewise formed by mixing a solution of sulphate of copper with an excess of a solution of bichromate of potassa and then adding gradually caustic potassa. The precipitate produced is at first light, but becomes afterwards crystalline and darker. The salt is very nearly insoluble in water; it dissolves in caustic ammonia and its carbonate with a deep yellow colour, the warm saturated solution deposits upon cooling a salt in very brilliant green prisms of golden-yellow opalescence, which appears to be the chromate of copper-ammonia, which Malaguti prepared in another manner.

Chromate  
of copper-  
potassa.

According to Sugden Evans(1), the yellowish-brown precipitate produced by chromate of potassa in solution of copper, contains, even after perfect edulcoration, chromate of potassa, which may be extracted by hot water after the compound has been ignited. He found a well-washed precipitate of this description to contain 40·6 per cent of protoxide of copper, 54·6 of chromic acid, 1·7 of potassa, and 3·1 of water.

**Uranium.**—For the preparation of uranium-compounds on the large scale, A. Patera(2) proposes roasting the finely-crushed pitch-blende-ore, intimately mixed with half its weight of caustic lime, for several hours at a dark red-heat in a reverberatory furnace, the mixture being repeatedly stirred; mixing with water, extracting the sesquioxide of uranium with sulphuric acid, removing the copper and antimony from the feebly acid solution by metallic iron, and then precipitating the basic sulphate of protoxide of uranium by addition of an excess of water, and separating the precipitate rapidly from the supernatant liquid; it may be freed from an admixture of basic salt of sesquioxide of iron by re-solution in the smallest possible amount of sulphuric acid and re-precipitation by water.

**Arsenic. Arseniates.**—We abstract the following from an investigation on the arseniates by Kotschoubey(3):—The double-salt of potassa and soda has, according to this chemist, the formula  $\text{NaO}, \text{KO}, \text{HO}, \text{AsO}_5 + 18 \text{HO}$ .—He states that the following lime-salts may be prepared:  $2 \text{CaO}, \text{HO}, \text{AsO}_5 + 3 \text{HO}$ , by adding neutral arseniate of soda drop by drop to chloride of calcium and drying the crystalline precipitate in the water-bath;  $2 \text{CaO}, \text{HO}, \text{AsO}_5 + 2 \text{HO}$ , by careful addition of chloride of calcium to arseniate of soda and desiccation of the precipitate at  $100^\circ$ ;  $3 \text{CaO}, \text{AsO}_5 + 3 \text{HO}$ , by mixing arseniate of potassa

(1) Chem. Soc. Qu. J. II, 218.

(2) Wien. Acad. Ber. May, 1849, 353.

(3) Petersb. Acad. Bull. VIII, 129; J. Pr. Chem. XLIX, 182.

**Arsenic.** with ammonia and adding chloride of calcium;  $2 \text{CaO}, \text{NH}_4\text{O}, \text{AsO}_5$   
**Arseniates.**  $+ 12 \text{HO}$ , by addition of ammonia to a solution of the neutral lime-salt in hydrochloric or nitric acid: this salt may likewise be obtained from a mixture of chloride of ammonium, arseniate of soda, and chloride of calcium, as a crystalline salt, becoming  $2 \text{CaO}, \text{NH}_4\text{O}, \text{AsO}_5 + 2 \text{HO}$ , at  $125^\circ$ ;  $\text{CaO}, 2 \text{HO}, \text{AsO}_5 + \text{HO}$ , is obtained, by solution of the neutral salt in excess of arsenic acid and evaporation, in lamellar crystals that are altered on exposure to air;  $6 \text{CaO}, \text{AsO}_5 + 6 \text{HO}$  was formed after some time in a dilute solution, containing arseniate of soda and an excess of chloride of calcium, as an amorphous mass, becoming anhydrous at  $120^\circ$ .—The baryta-salts investigated by him are:  $2 \text{BaO}, \text{HO}, \text{AsO}_5 + 2 \text{HO}$  (dried at  $100^\circ$ ), obtained by addition of chloride of barium to a hot solution of arseniate of soda, in white scales of silky lustre, slightly soluble in acids in the cold, but easily soluble in them when heated;  $2 \text{BaO}, \text{NH}_4\text{O}, \text{AsO}_5 + 4 \text{HO}$ , prepared by addition of ammonia to a solution of the foregoing salt in acids.—The strontia-salt,  $2 \text{SrO}, \text{HO}, \text{AsO}_5 + 3 \text{HO}$ , is soluble in acetic acid, very easily soluble in hydrochloric acid, and is decomposed by hot water, forming a soluble acid salt and a basic salt. The precipitate, obtained by the gradual addition of an aqueous solution of arsenic acid to acetate of magnesia, or by adding neutral arseniate of soda to sulphate of magnesia, is, according to Kotschoubey,  $2 \text{MgO}, \text{HO}, \text{AsO}_5 + 13 \text{HO}$ .

**Double Arseniates.**—When arseniate of magnesia-ammonia, from which the water and ammonia have been expelled by heat, is mixed in proper proportions with an alkaline carbonate and ignited, there is formed, according to H. Rose(1), an insoluble compound which contains 1 equivalent of arsenic acid to 2 of earth and 1 of alkali, which is however as difficult to obtain pure (chiefly on account of the decomposing action of the water in washing it) as the corresponding compound of phosphoric acid (compare page 157). Neither the experiments with arseniate of magnesia-potassa nor those upon arseniate of magnesia-soda furnished the insoluble double-salt in its pure state.

**Teriodide of Arsenic.**—Göpel(2) has made some experiments upon the best method of preparing iodide of arsenic,  $\text{AsI}_3$ . He found it to be as follows:—2 drachms of iodine and 1 drachm of finely-powdered arsenic, are mixed and maintained in fusion for some time in a digesting flask upon a sandbath at as low a temperature as possible; the mixture when cool is treated with 4 ounces of cold alcohol, the solution is poured off from the residual arsenic, its colour reduced to a wine-yellow by subjection to a current of arseniatted hydrogen, and then evaporated immediately, at a temperature not exceeding  $50^\circ$ , until it crystallises. With respect to the method proposed by

(1) Loc. cit. 157.

(2) Arch. Pharm. [2] LX, 129.

Meurer(1), of passing arseniетted hydrogen into an alcoholic solution of iodine, Göpel states that the former may contain free hydrogen without injury to the process, and that the treatment with the gas should be interrupted when the liquid becomes of a pale wine-yellow colour; he found that the chocolate-brown powder, deposited after too long a treatment of the liquid with arseniетted hydrogen, was composed according to the formula  $\text{AsI}$ .

Teriodide  
of arsenic.

**Antimony.**—According to Strohl(2), terchloride of antimony forms with hyposulphite of soda and water, slowly in the cold, and rapidly at the boiling temperature, a beautiful crimson precipitate which he considers to be  $\text{SbS}_3 + \text{SbO}_3$ , and the formation of which he explains by the following decomposition,  $2 \text{SbCl}_3 + 3 (\text{NaO}, \text{S}_2\text{O}_2) + 6 \text{HO} = (\text{SbS}_3 + \text{SbO}_3) + 3 (\text{NaO}, \text{SO}_3) + 6 \text{HCl}$ . To obtain this compound pure, Strohl recommends the following proportions, 60 of crystallised hyposulphite of soda, 50 of solid terchloride of antimony, and 500 of water. This substance, which Strohl calls *antimony-cinnabar*, retains its colour when exposed to air and light; when heated it becomes darker and fuses to a black mass.—Pettenkofer(3) had prepared this compound previously according to instructions given to him by Unger, and observed that in its production abundance of sulphurous acid is disengaged, even when an excess of hyposulphite of soda is avoided; according to this, the reaction given by Strohl cannot be correct. He also found that the antimony-cinnabar thus prepared contained considerable quantities of terchloride of antimony.

A paper by Derouen(4) on kermes, and the best method of preparing it, does not appear to us to need any abstract. Derouen regards kermes as hydrated tersulphide of antimony, and believes that its production is always accompanied by the formation of a combination of tersulphide of antimony with an alkaline sulphide, which is decomposed by the carbonic acid of the air, or by another acid.

According to Laroque(5), the terchloride of antimony, prepared by treating the crude tersulphide of antimony with an excess of hydrochloric acid, and applying heat, evaporating the solution and distilling, is then free from arsenic, because the tersulphide of arsenic contained in the solution is separated, in the distillation, before the terchloride of antimony passes over. The hydrochloric acid that volatilises first in the distillation, contains, according to Laroque, only little terchloride of antimony, but the whole of the tersulphide of arsenic; the terchloride of antimony that passes over afterwards, is free from arsenic, if the receiver has been changed at the proper time.

(1) Annual Report for 1847 and 1848, I, 325.

(2) J. Pharm. [3] XVI, 11.

(3) Dingl. Pol. J. CXIII, 215.

(4) J. Pharm. [3] XV, 5; Chem. Gaz. 1849, 431.

(5) J. Pharm. [3] XV, 161; Chem. Gaz. 1849, 436.



Tellu-  
rium.

**Tellurium.**—Hartung-Schwarzkopf(1) found, contrary to what has hitherto been known, that amorphous tellurium, obtained by precipitation of a solution of tellurous acid by means of sulphurous acid, did not dissolve in concentrated nitric acid, and that the two bodies had no action upon each other, even when heat is long continued.

**Tin.**—In the analysis of Banka tin (containing 99·961 per cent of tin, 0·006 of copper, 0·014 of lead, and 0·019 of iron), Mulder(2), who estimated the tin as binoxide, and used as equivalent of this metal the number 58·824, determined by Berzelius, obtained an excess of tin. He considers that the equivalent of this metal is lower than the above number; from 100 of pure tin he obtained, in one experiment, 127·56, Vlaanderen 127·56 and 127·43 of binoxide of tin; from these results Mulder fixes the equivalent of tin at 58 (100 of tin should then yield 127·59 of binoxide.)

**Lead.**—Bolley(3) designates as *spongy lead*, the metal obtained in the following manner. Sulphate of lead, mixed to a paste with water, spread an inch thick upon a zinc plate, covered with another zinc plate, and immersed in the upper portion of a solution of chloride of sodium, not perfectly saturated, is converted after the lapse of a few days into a coherent soft mass of lead, which may be freed from the solution of salt contained in its interstices, by immersion in hot water. This mass may be converted into a solid pliable plate of lead, by means of a powerful press; it may be formed into models, and yields impressions of great sharpness. When submitted to less powerful pressure, the mass is easily oxidised.

Bley(4) had stated that, by igniting nitrate of lead, a compound of protoxide of lead with nitrogen  $2\text{PbO} + \text{N}$  was formed. Stammer(5) has arrived at the result, that the dirty yellow-red compound, obtained in this experiment, is only a mixture of protoxide of lead with red lead.

**Compounds of Protoxide of Lead and Nitrogen-Acids.**—Th. Bro-meis(6) has investigated the salts produced by the action of nitrate of lead upon lead. These salts were prepared in such a manner that the solution of nitrate of lead was placed in contact with an excess of lead shavings, in different proportions and for different periods, principally at the boiling temperature. The evolution of binoxide of nitrogen, commencing at about  $80^{\circ}$ , becomes scarcely perceptible at a subse-

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(1) Arch. Pharm. [2] LVIII, 150.

(2) Scheikundige Onderzoekingen V, 259; J. Pr. Chem. XLVIII, 31; J. Pharm. [3] XVII, 51; Chem. Gaz. 1849, 344.

(3) Jahrb. Pr. Pharm. XVIII, 380.

(4) J. Pr. Chem. XXXIX, 23.

(5) Ann. Ch. Pharm. LXX, 296.

(6) Ann. Ch. Pharm. LXXII, 38; Gerhardt's observations on these salts, compare Laur. and Gerh. C. R. 1850, 168.

quent period of the operation; the fluid assumes at first a yellow colour, and then gradually diminishes in intensity of colour, without, however, becoming again perfectly colourless. It does not appear that any salt but that first formed can be obtained pure. All the salts retain their form upon ignition, excepting the one first formed, which fuses in its water of crystallisation. The solution of the salts in water, not perfectly free from air, is always turbid; their solubility decreases in proportion as the amount of base increases; the salts are soluble with difficulty in cold, and more easily in boiling water, and easily soluble in acetic acid; a concentrated solution in the latter solvent, exhibits, below a yellowish solution, a heavy oily liquid, which, by exposure to heat for some time, becomes a gummy, very sticky mass. Alcohol and ether precipitate these salts from their solutions as yellowish-white powders; nitrate of copper gives with them a light bluish-green precipitate, nitrate of suboxide of mercury a yellow one, which becomes immediately dingy-green, and finally brownish-black. The salts have an alkaline reaction. With the exception of the quadri-basic nitrate, they are all decomposed at  $85^{\circ}$ .—The first action of nitrate of lead upon lead produces bibasic hyponitrate of lead. Bromeis prepared this according to Péligot's method, by boiling together equal equivalents of both substances; it crystallises in straw-coloured brilliant laminæ, in the form of rectangular prisms, with rhombic pyramids; Bromeis confirmed Péligot's formula  $2\text{PbO}, \text{NO}_4 + \text{H}_2\text{O}$ . The salt dissolves, at the ordinary temperature, in 85 times its weight of water. It begins to decompose at  $85^{\circ}$ ; it fuses, at a higher temperature, in its water of crystallisation, and intumescs considerably.—After the solution of nitrate of lead had been maintained in ebullition for several days, in contact with a large excess of lead, it deposited, simultaneously with a green salt to be described presently, single, hard light-brick-red, rhombic crystals ( $\infty \text{P} : \infty \text{P} = 123^{\circ}$ ;  $\check{\text{P}} \infty : \check{\text{P}} \infty = 63^{\circ}$ ; cleavage parallel to  $0 \text{P}$ ); their analysis furnished the atomic proportions  $7\text{PbO}, \text{NO}_4, \text{NO}_5, 3\text{HO}$ .—Bromeis confirmed Péligot's statements respecting the orange-coloured salt  $7\text{PbO}, 2\text{NO}_4 + 3\text{HO}$ , first prepared by the latter, and likewise produced by boiling the solution of  $2\text{PbO}, \text{NO}_4 + \text{HO}$  with lead; once in endeavouring to prepare the foregoing salt, an orange-coloured but more brilliant salt was obtained, the analysis of which led to the formula  $3\text{PbO}, \text{NO}_3 + 4\text{PbO}, \text{NO}_4 + 3\text{HO}$ .—Bibasic nitrite of lead is produced, although in small quantities, by boiling a solution of  $2\text{PbO}, \text{NO}_4 + \text{H}_2\text{O}$  for some time with lead; it is deposited, as the solution cools, upon the other salt, in tolerably long golden-yellow needles (twin-like contorted rectangular prisms, with rhombic pyramids), the composition of which is expressed by the formula  $2\text{PbO}, \text{NO}_3 + \text{HO}$ .—Tribasic nitrite of lead (of which Péligot denied the existence) is always produced, according to Bromeis, when the solution of the orange salt is boiled for some

Com-  
pounds of  
protoxide  
of lead and  
nitrogen-  
acids.

Com-  
pounds of  
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of lead and  
nitrogen-  
acids.

hours with lead; when the liquid cools, it is deposited upon the sides of the vessel, in small needles, generally united in concentric groups, which are sometimes bright red, sometimes green, and are always composed according to the formula  $3 \text{PbO}, \text{NO}_3$ .—Quadribasic nitrite of lead—which is the salt formed by the ultimate action of nitrate of lead upon lead, in very dilute solutions, and was obtained flesh-coloured by Chevreuil, and of a faint rose-colour by Péligot—was also prepared by Bromeis of a light greenish-brown colour. He confirmed the formula  $4 \text{PbO}, \text{NO}_3 + \text{HO}$ , for this salt; the water escapes at a temperature above  $150^\circ$ .

**Iron.**—Poumarède(1) states, in a paper of which only an abstract has been published, that zinc partly reduces the salts of protoxide of iron at a somewhat elevated temperature, iron being precipitated of its usual colour and of the sp. gr.  $7.50$ ; protochloride of iron may be reduced by the vapour of zinc with the aid of coal, the iron thus produced assumes a dendritic form, and is sometimes obtained in hollow tetrahedra; its sp. gr. is  $7.84$ .—Augustine(2) has detected distinct cubes on the fractured surfaces of gun barrels that had been long in use.

With regard to the proposals of Desfosses(3) and Frickhinger(4) for the preparation of *aethiops martialis*, and of Jonas(5) for the preparation of protiodide of iron, *tinctura ferri iodati* and *tinctura ferri muriatici*, we must refer to the original papers mentioned below.

**Cobalt.**—Louyet(6) recommends the following process (the principle of which has been long known) for the preparation of protoxide of cobalt free from iron. Sulphate of cobalt, containing sesquioxide of iron, is mixed with gelatinous hydrate of protoxide of cobalt, or partly precipitated by carbonate of soda, and maintained at the boiling temperature for some time. The iron is perfectly precipitated by this means as the cobalt becomes dissolved in its stead.

Louyet has found, moreover, with reference to the combination of protoxide of cobalt with alumina, known as Thenard's blue, that a mixture of hydrate of alumina and hydrate of protoxide of cobalt, furnishes the blue colour only at a temperature approaching the fusing-point of glass, and that the mixture becomes merely black or grey at a red-heat, while a mixture of hydrate of alumina and phosphate, or arseniate of cobalt produces the blue colour even at a red-heat.

Rammelsberg(7) has made some experiments on the composition

(1) Compt. Rend. XXIX, 518.

(2) Dingl. Pol. J. CXII, 76.

(3) J. Pharm. [3] XVI, 81.

(4) Repert. Pharm. [3] IV, 1.

(5) Arch. Pharm. [2] LIX, 257.

(6) Instit. 1849, 206; Laur. and Gerh. C. R. 1849, 368; J. Pr. Chem. XLVII, 402; Comp. Herschel's method, which is also applicable to analysis, Ann. Ch. Phys. [2] XLIX, 306.

(7) Pogg. Ann. LXXVIII, 93.

of the residue, obtained on the ignition of the hydrate, the carbonate and oxalate of cobalt in the air or in oxygen; he has determined the amount of metal it contains by reduction with hydrogen. He found the residue from hydrated protoxide of cobalt to contain 74.28 per cent of metal; that from the carbonate contained between 72.69 and 74.44 per cent, and that from the oxalate between 73.62 and 74.33 per cent. In these cases, therefore,  $\text{Co}_3\text{O}_4 = \text{CoO}$ ,  $\text{Co}_2\text{O}_3$  (which contains 73.46 per cent of cobalt) was formed. Winkelblech and Beetz, on the other hand, had obtained by the ignition of hydrated protoxide of cobalt,  $\text{Co}_6\text{O}_7$  (which contains 75.98 per cent of cobalt); and the latter proposed that this compound should be employed for the quantitative determination of cobalt on account of its stability. Rammelsberg states that it depends upon the temperature whether  $\text{Co}_3\text{O}_4$  or  $\text{Co}_6\text{O}_7$  is formed, as a faint heat yields  $\text{Co}_3\text{O}_4$ ; at any rate the analytical determinations of cobalt cannot be made with certainty from the residue obtained by the ignition of cobalt-precipitates, but only by the reduction by means of hydrogen.

Rammelsberg found the sp. gr. of cobalt, reduced by hydrogen, in 5 experiments to be from 8.132 to 9.495 (mean, 8.957); that of  $\text{Co}_3\text{O}_4$  he found, in 3 experiments, to be from 5.833 to 6.296; mean, 6.073.

**Nickel.**—The sp. gr. of nickel, reduced by hydrogen, he found to be 8.975 and 9.261; that of protoxide of nickel, 6.661.

**Copper.**—Persoz(1) endeavours, in a long paper, to defend the view, that protoxide of copper must be considered as a combination of suboxide of copper with oxygen, and sulphate of copper as  $(\text{Cu}_2\text{O}) \text{O}$ ,  $2 \text{SO}_3 + \text{Aq}$ . He endeavours, by this assumption, to explain a few remarkable reactions of the salts of protoxide of copper, and particularly the circumstance, that sulphate of protoxide of copper and sulphate of potassa form, besides a double-salt of both, basic salts and bisulphate of potassa. According to this chemist, a basic sulphate of copper,  $3 \text{CuO}$ ,  $\text{SO}_3 + 2 \text{HO}$ , is moreover formed in this reaction. He states that a corresponding basic chromate is produced by the action of neutral chromate of potassa upon sulphate of copper by heating, it is converted into a mixture of the compound  $\text{CuO}$ ,  $\text{Cr}_2\text{O}_3$ , and protoxide of copper, of which the former is not attacked by hydrochloric acid. A more perfect abstract of this paper cannot be given here, we must therefore refer to the original communication for the details of his various views; we will confine ourselves to the fact that Persoz recommends for the analysis of copper-salts, with the exception of the phosphate, that they be fused with nitre until the resulting nitrate of copper is decomposed, and that the protoxide of

(1) Ann. Ch. Phys. [3] XXV, 257; Ann. Ch. Pharm. LXX, 321; J. Pr. Chem XLVII, 75.

**Copper.** copper should be determined, which separates upon the solution of the fused mass.—Kühn(1) has endeavoured to prove the unsoundness of the theoretical views of Persoz. .

**Mercury. Action of the Protochloride of Mercury upon the Protoxide of Mercury.**—Roucher(2) has studied the action of protochloride of mercury on the yellow and the red modification of the protoxide of mercury, and the influence of different solvents and of the temperature upon the results.

He considers the following to be the general results of his researches: The products of the action of the chloride upon the oxide, when accomplished under the influence of heat, are always the same, whatever modification of the oxide, or whatever solvent (water or alcohol) for the chloride be employed; insoluble black  $\text{HgCl}$ ,  $2 \text{HgO}$ , which contains red protoxide, and white somewhat soluble  $2 \text{HgCl}$ ,  $\text{HgO}$  are formed.—In the cold, the yellow oxide always forms yellow  $\text{HgCl}$ ,  $3 \text{HgO}$ . The red oxide forms in the cold, with excess of solution of the chloride, whichever solvent be employed, black  $\text{HgCl}$ ,  $2 \text{HgO}$ ; if the oxide is present in excess, a livelier action and formation of  $\text{HgCl}$ ,  $6 \text{HgO} + \text{HO}$  ensues, but only when water is employed as solvent. Friction has likewise some influence on the nature of the products of the reaction; by its aid,  $\text{HgCl}$ ,  $4 \text{HgO}$  was obtained in the cold from red oxide.

Roucher has stated moreover in what modification the protoxide of mercury must be assumed to exist in its various combinations with the protochloride. As *red* oxide: in  $\text{HgCl}$ ,  $2 \text{HgO}$ , small black laminæ, produced by the continuous boiling of the oxide with an excess of chloride; in  $\text{HgCl}$ ,  $4 \text{HgO}$ , dark-brown laminæ, formed by boiling the mother-liquor obtained in the treatment of the chloride with carbonate of potassa; in  $\text{HgCl}$ ,  $4 \text{HgO}$ , the almost amorphous body, formed in the cold from the chloride and red oxide, under the influence of friction; in  $\text{HgCl}$ ,  $5 \text{HgO}$ , blackish-brown needles formed by the slow action of the chloride upon an excess of the red oxide in the cold; in  $\text{HgCl}$ ,  $6 \text{HgO}$ , dark-brown small laminæ, formed from excess of the red oxide with the chloride in the cold; in  $\text{HgCl}$ ,  $6 \text{HgO} + \text{HO}$ , produced in the cold from an excess of red oxide by frequent removal of the solution of chloride.—It exists as *yellow* oxide: in  $2 \text{HgCl}$ ,  $\text{HgO}$ , as produced by solution of the oxide in cold or hot solution of chloride; in  $\text{HgCl}$ ,  $2 \text{HgO}$ , precipitated, of a light-brick-red colour, from a solution of chloride by bicarbonate of potassa; in  $\text{HgCl}$ ,  $2 \text{HgO}$ , as precipitated, of a purple or violet colour, by addition of 3 or 4 volumes of solution of chloride to 1 volume of solution of a bicarbonate of an alkali; in  $\text{HgCl}$ ,  $3 \text{HgO}$ , precipitated, of a brick-

(1) Ann. Ch. Pharm. LXXIII, 80.

(2) Ann. Ch. Phys. [3] XXVII, 353; J. Pr. Chem. XLIX, 363.

red colour, from an excess of boiling solution of the chloride by carbonate of potassa; in  $\text{HgCl}$ ,  $3 \text{ HgO}$ , as precipitated in light-brown laminæ from 1 volume of solution of the chloride by 1 volume of bicarbonate of potassa; in  $\text{HgCl}$ ,  $3 \text{ HgO}$ , produced in the amorphous state from yellow oxide and the chloride in the cold; in  $\text{HgCl}$ ,  $4 \text{ HgO}$ , brown laminæ of golden lustre, which are deposited on the cooling of a solution in which  $\text{HgCl}$ ,  $2 \text{ HgO}$ , and  $\text{HgCl}$ ,  $3 \text{ HgO}$ , &c., have been heated to ebullition; in  $\text{HgCl}$ ,  $4 \text{ HgO}$ , obtained of a different appearance and amorphous, by exhausting  $\text{HgCl}$ ,  $2 \text{ HgO}$ , and  $\text{HgCl}$ ,  $3 \text{ HgO}$  with boiling water; in  $\text{HgCl}$ ,  $6 \text{ HgO}$ , formed as an amorphous substance by the action of an excess of the yellow oxide on the chloride in the cold.

Mercury.  
Action of  
the proto-  
chloride of  
mercury  
upon the  
protoxide  
of mer-  
cury.

**Iodide of Mercury.**—For the preparation of iodide of mercury, Dublanc(1) recommends to cover 100 grms. of mercury with 1 kilogram. of alcohol, to add 124 grms. of iodine, gradually in portions of 10 grms, and agitating between each fresh addition, until the alcohol becomes colourless again. After the addition of the last 4 grms. the alcohol remains coloured, the whole of the mercury having become converted into iodide. The resulting preparation is washed with alcohol; it is crystalline and of a hyacinth colour.

**Nitrate of Suboxide of Mercury**—Marignac(2) and Gerhardt(3) have investigated the compounds of suboxide of mercury with nitric acid.

If dilute nitric acid is allowed to act upon an excess of mercury at a gentle heat, until the first powerful action has become more feeble, and the liquid, which is still powerfully acid, poured off, it deposits, upon cooling, crystals of neutral nitrate of suboxide of mercury. The formula  $\text{Hg}_2\text{O}$ ,  $\text{NO}_5 + 2 \text{ HO}$ , assigned to these crystals by C. G. Mitscherlich, has been confirmed by Marignac and Gerhardt; according to the statements of both, they belong to the monoclinometric system; the predominant planes are, according to the position chosen by Marignac,  $\infty \text{ P}$ ,  $\infty \text{ P } \infty$ ,  $(\infty \text{ P } \infty)$ ,  $+ \text{ P } \infty$ ,  $- \text{ P } \infty$ ,  $(\text{P } \infty)$  and the most important inclinations, according to the accurate measurements of the latter,  $\infty \text{ P} : \infty \text{ P}$  in the clinodiagonal principal section  $= 83^\circ 40'$ ;  $+ \text{ P } \infty : \infty \text{ P } \infty = 116^\circ 35'$ ;  $- \text{ P } \infty : \infty \text{ P } \infty = 134^\circ 45'$ ;  $(\text{P } \infty) : (\text{P } \infty)$  in the clinodiagonal principal section  $= 102^\circ 2'$ ; inclination of the principal axis to the clinodiagonal  $76^\circ 12\frac{1}{2}'$ . According to Marignac, the crystals, when finely powdered, become anhydrous by exposure *in vacuo* over sulphuric acid.

Gerhardt states that the solution of mercury in warm dilute nitric

(1) J. Pharm. [3] XV, 164.

(2) Ann. Ch. Phys. [3] XXVII, 315; Ann. Ch. Pharm. LXXII, 55.

(3) Laur. and Gerh. C. R. 1849, 225; Ann. Ch. Pharm. LXXII, 74. Collection of the results of both researches, by Marignac in Arch. Ph. Nat. XII, 51, by Gerhardt in his and Laurent's Compt. Rend. des Trav. Chim. 1849, 408.

Nitrate of  
suboxide of  
mercury.

acid deposits frequently, instead of the neutral salt, prismatic crystals of a basic salt, which however pass over into the neutral salt, if allowed to remain for some time in the acid liquid. The same salt is formed, according to Marignac, if the crystals of the neutral salt, together with the mother-liquor from which they were deposited, are heated together with an excess of mercury, and the liquid allowed to crystallise by cooling (the basic-salt mentioned below is, however, frequently formed at the same time). These prismatic crystals belong to the rhombic system; they generally exhibit  $\infty P . \infty \bar{P} \infty . 0 P$ , sometimes in  $\bar{P} \infty$  and subordinate secondary pyramids; according to Marignac  $\infty P : \infty P = 83^\circ 52'$ ;  $m \bar{P} \infty : m \bar{P} \infty$  in the macro-diagonal principal section  $= 130^\circ 24'$ . The analyses of Marignac and Gerhardt agree, but these chemists deduce different formulæ from their results, as Gerhardt assumes the amount of mercury obtained to be too low. Marignac's formula for the crystallised salt is  $4 \text{Hg}_2\text{O}, 3 \text{NO}_5 + \text{HO}$ , that assigned to it by Gerhardt is  $3 \text{HgO}, 2 \text{NO}_5 + \text{HO}$ .

	Experiment.		Theory.	
	Marignac.	Gerhardt.	Marignac.	Gerhardt.
Protoxide of mercury	82.5	82.2 to 82.5	82.95	84.21
Nitrogen . . . . .	4.2 to 4.5	—	4.19	3.78
Water . . . . .	1.1 to 1.3	1.9	0.90	1.21

If neutral nitrate of suboxide of mercury is suspended in a little water, and heated to ebullition therewith, the filtered solution deposits upon cooling brilliant trichlinometric prisms of another basic salt (Gerhardt). The same prisms are formed, according to Marignac, by boiling the solution or the mother-liquid of one of the foregoing salts for several hours with an excess of mercury, the water being replaced as it evaporates, and cooling the resulting solution; or by allowing the crystals of one of the foregoing salts to stand, at the common temperature, together with their mother-liquor and an excess of metallic mercury, when they will pass over gradually into the hard and brilliant, permanent trichlinometric crystals. Angular measurements of these crystals have been made by Gerhardt, and with particular accuracy by Marignac; we must refer to the original papers respecting them. The composition of these crystals is, according to Marignac,  $5 \text{Hg}_2\text{O}, 3 \text{NO}_5 + 2 \text{HO}$ , and according to Gerhardt (who assumes in this case also that the mercury-determinations were too low)  $2 \text{Hg}_2\text{O}, \text{NO}_5 + \text{HO}$ .

	Experiment.		Theory.	
	Marignac.	Gerhardt.	Marignac.	Gerhardt.
Protoxide of mercury	85.2	85.2 to 85.3	85.24	86.85
Nitrogen . . . . .	3.4 to 3.5	—	3.44	1.88
Water . . . . .	1.7	2.0 to 2.2	1.48	2.98

Marignac and Gerhardt found the light-yellow powder which is produced by the action of cold water on one of the foregoing salts, and is decomposed by hot water, to have the formula already assigned to it by Kane,  $2 \text{Hg}_2\text{O}$ ,  $\text{NO}_5 + \text{HO}$  (Gerhardt considers it to be the last-mentioned salt, in the amorphous state).

Nitrate of  
suboxide of  
mercury.

The following is communicated, in addition, by Gerhardt :

If a solution of nitrate of suboxide of mercury is evaporated, the sides of the vessel, where the temperature is rather higher, become coated with a light-yellow salt of the sub- and protoxide, which is identical with the salt  $\text{Hg}_2\text{O}$ ,  $2 \text{HgO}$ ,  $\text{NO}_5$  analysed by Brooks. The same salt is formed, with evolution of binoxide of nitrogen, upon fusing nitrate of suboxide of mercury.

Gaseous hyponitric acid converts mercury into a white crystalline salt which is not nitrite of oxide of mercury, but neutral nitrate of suboxide of mercury, the formation of which is accompanied, in this case, by the evolution of binoxide of nitrogen.

On addition of phosphate of soda to an excess of nitrate of suboxide of mercury, dissolved in nitric acid, a white or pale yellowish crystalline precipitate is formed, which may be washed with cold water, and is  $\text{Hg}_2\text{O}$ ,  $\text{NO}_5 + 3 \text{Hg}_2\text{O}$ ,  $\text{PO}_5 + 2 \text{HO}$ . If, on the other hand, nitrate of suboxide of mercury is added to an excess of phosphate of soda, the resulting precipitate is not crystalline, but tribasic phosphate of suboxide of mercury; when gently heated in a tube, this salt evolves metallic mercury, and becomes tribasic phosphate of protoxide of mercury, which is yellow when hot, but white when cold, and may also be obtained by addition of nitrate of protoxide of mercury to an excess of phosphate of soda. On addition of phosphate of soda to an excess of nitrate of protoxide of mercury, a double-salt of phosphate and nitrate of protoxide of mercury is produced.

**Amidogen-Compounds of Mercury.**—Schrötter(1) has endeavoured to show that the amidogen-compounds of mercury are multiples of sub- or protoxide, or sub- or protochloride of mercury, in which 1 or more equivalents of oxygen or chlorine are replaced by amidogen; he has founded a new nomenclature for these compounds upon this view.

**Silver.**—Wittstein(2) recommends the reduction of chloride of silver by heating to redness an intimate mixture of 2 parts of that substance with 1 part of charcoal. He states that the reduction is solely affected by the hydrogen of the charcoal.—Bolley(3) found that silver may easily be separated in the metallic state from its solutions, containing copper, by cane-sugar in the presence of caustic ammonia or potassa and application of heat; the precipitate should be first washed with hot water, and afterwards with hot acetic acid.

(1) Wien. Acad. Ber. Jan., 1849, 4; Repert. Pharm. [3] III, 393.

(2) Repert. Pharm. [3] II, 1.

(3) Jahrb. Pr. Pharm. XVIII, 384.



Plati-  
num.

**Platinum.**—According to an investigation of Laurent and Gerhardt(1), chloride of ammonium-bichloride of platinum, upon digestion with concentrated solution of ammonia dissolves gradually, forming an almost colourless solution, from which alcohol precipitates a large quantity of white flakes, which dry up to a resinous, pale-yellow mass, easily soluble in water; a great deal of chloride of ammonium remains in solution. The composition of the resinous mass dried at  $160^{\circ}$ , corresponded to the formula  $\text{PtClN}_2\text{H}_5$ , according to which its formation would be explained by the equation  $\text{PtCl}_2, \text{NH}_4\text{Cl} + \text{NH}_3 = \text{PtClN}_2\text{H}_5 + 2 \text{HCl}$ ; when heated above  $210^{\circ}$  it evolves hydrochloric acid, and becomes insoluble. Its solution gives with oxalate, sulphate and carbonate of ammonia, white precipitates, which did not, however, exhibit any constant composition, neither could they be obtained crystallised. Laurent and Gerhardt believe that this resinous mass is the chlorine-compound of a base similar to those described by Gros and Reiset.

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(1) Laur. and Gerh. C. R. 1848, 113; Ann. Ch. Pharm. LXXIII, 223; J. Pr. Chem. XLVI, 511. Fischer's former observations, comp. Kastner's Archiv. XIV, 150; Gmelin's Handb. Chem., 4. ed. III, 747.

# ORGANIC CHEMISTRY.

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**Generalities. Fermentation.**—Schubert(1) has published an investigation upon yeast. In order to prove that the action of yeast is due merely to its porosity, he founds his investigation upon some experiments of Brendecke(2), according to which various porous bodies, such as charcoal, paper, flowers of sulphur, &c., to which some bitartrate of ammonia is added, are capable of inducing fermentation in a solution of raw sugar. His observations are also based upon some experiments of his own, which seem to indicate that porous bodies, even without the addition of a salt, are capable of exciting fermentation in a solution of (pure?) cane-sugar. Whatever may be the means whereby alcoholic fermentation is induced, he states it to be indispensable that the body in question should be exposed for some time to the influence of air, and that oxygen and carbonic acid are absorbed by the ferment. Both oxygen and carbonic acid, being electro-negative substances, stand in opposition to the electro-positive alcohol, and therefore predispose its formation, but only when they are highly condensed by the powerful surface-attraction of the yeast or of any porous body. The electrical tension, he states, may be increased by many salts, provided that the latter do not at the same time chemically affect either the sugar or the ferment.

General-  
ities.  
Fermenta-  
tion.

**Cyanogen-Compounds. Constitution.**—Schrötter(3) has added one more to the views which have been advanced regarding the double cyanides. According to his observations they may all be referred to the types  $nMCy$  and  $M_5Cy_6$ , wherein  $M$  represents an equivalent of metal and  $n$  the numbers 1, 2, 3, and 11;  $nM$  or  $5M$  may be represented by one or by several metals; in like manner a portion of the cyanogen in the cyanides  $2MCy$  and  $3MCy$  may be replaced by chlorine, bromine, iodine, or oxygen. The cyanides  $KCy$ ,  $KZnCy_2$ ,  $K_2FeCy_3$ , and (Quadrat's salts)  $M_6Pt_5Cy_{11}$ , correspond to

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(1) Pogg. Ann. LXXVII, 197.

(2) Comp. Annual Report for 1847-8, I, 357, particularly in reference to the statement that fermentation taking place in a solution of sugar in contact with porous bodies is due to an impurity of the sugar.

(3) Wien. Acad. May, 1849, 316.

Cyanide of  
lead.

the formula  $nMCy$ . Ferricyanide of potassium,  $K_3Fe_2Cy_6$ , and its corresponding salts, are composed according to the formula  $M_3Cy_6$ .

**Cyanide of Lead.**—E. Erlenmeyer(1) has studied the composition of the precipitate which is formed in an aqueous or alcoholic solution of basic acetate of lead, by hydrocyanic acid and subsequent addition of ammonia or potassa. It agrees with the formula  $2PbO, PbCy$ . He states that the compound must be washed with exclusion of air, and very carefully dried. By this the different results obtained by Kugler(2) in the analysis of the same compound are explained.—Cyanide of ammonium produces in solution of acetate of lead a trifling yellowish precipitate; however hydrocyanic acid alone gives no precipitate in a solution of either nitrate or neutral or basic acetate of lead. •

**Ferricyanide of Potassium and Sodium.**—According to the observations of Laurent(3), if a solution of a mixture of ferricyanide of potassium and ferricyanide of sodium be left to spontaneous evaporation, a deposition takes place of garnet-coloured cubic crystals, which are anhydrous, and when gently heated decrepitate to a powder. Analysis led to the formula  $Fe_4Cy_{12}, K_3Na_3$ . On one occasion Laurent obtained the salt in the hydrated condition, in large blackish-brown, six-sided prisms of about  $120^\circ$ . These crystals contained 6 equivs. of water, yielding on analysis 14.5 per cent; by recrystallisation, however, they passed into the anhydrous cubic salt.

**Prussian Blue.**—Chevreul(4), by his investigations on the deportment of Prussian blue in the light, has shown that when exposed on a plate of porcelain *in vacuo* to the influence of light the blue becomes decolorised with evolution of cyanogen or hydrocyanic acid; and when in contact with oxygen, it acquires again its blue colour with simultaneous formation of sesquioxide of iron. The sesquioxide of iron which is thus formed may be separated from the blue compound by hydrochloric acid. Chevreul's earlier experiments(5) on this subject were made with silk and cotton stuffs dyed with Prussian blue; but the sesquioxide of iron formed in these cases, even after five consecutive decolorisations could not be dissolved by hydrochloric acid.

**Nitroprussides.**—L. Playfair(6), in studying the action of nitric acid upon ferrocyanide of potassium, has discovered a new class

(1) J. Pr. Chem. XLVIII, 356; Ann. Ch. Pharm. LXXII, 265 (in abstr.).

(2) Annual Report for 1847 and 1848, I. 365.

(3) Laur. and Gerh. C. R. 1849, 324.

(4) Compt. Rend. XXIX, 294; Instit. 1849, 298; J. Pr. Chem. XLVIII, 187.

(5) Rev. Scientif. Industr. XXXVI, 74, 112, 151.

(6) Philos. Transact. 1849, II, 477; Phil. Mag. [3] XXXVI, 197, 271, 348; Laur. and Gerh. C. R. 1850, 170, (in abstr.); J. Pr. Chem. I, 36.

of salts which he terms *nitroprussides*. It had previously been observed by L. Gmelin(1) and others that the coffee-brown liquid which is obtained on decomposing ferrocyanide of potassium by means of nitric acid, acquires a beautiful blue or purple-red colour on addition of an alkaline metallic sulphide. These phenomena of coloration, as Playfair has proved, owe their origin to the decomposition, by the metallic sulphide, of the nitroprussides which are formed. In the course of his beautiful investigation, Playfair has made numerous and repeated analyses, and if future investigations should show that the formula he has adduced for the new salts are untenable, still the numbers which he has given will always be of great value for calculation. Before entering into the statements of the properties and composition of the salts investigated, he adduces some experiments whose results are of importance for the foundation of a theory regarding the constitution of the nitroprussides. In the action of nitric acid upon ferrocyanide of potassium, a copious evolution of binoxide of nitrogen takes place in the beginning of the operation, but after a short time it ceases entirely if the liquid be cooled down. At this point of the process a number of volatile products of decomposition are evolved, viz., cyanogen, hydrocyanic acid, nitrogen, carbonic acid, and, as we may conclude from the stifling pungent odour, probably also cyanic acid. The dark-red solution, on cooling, first deposits nitrate of potassa, and, if too much nitric acid has not been employed, a white body, which Playfair has recognised as *oxamide*. After heating or long standing, the solution no longer precipitates a salt of protoxide of iron of a blue, but of a dark-green or slate-colour. In order to ascertain in what relation the evolution of binoxide of nitrogen stands to the formation of nitroprussides, Playfair saturated cyanide of potassium with this gas. The gas was readily absorbed, the liquid at the same time acquired a red-colour, and deposited a body resembling paracyanogen. This solution by itself was not coloured on addition of a soluble metallic sulphide, the colouration, however, was immediately perceptible when a ferrocyanogen-compound was formed by adding a salt of protoxide of iron. The same result was manifested when a solution of sulphate of protoxide of iron saturated with binoxide of nitrogen was mixed with cyanide of potassium. Binoxide of nitrogen is not absorbed by a solution of ferrocyanide of potassium; if, however, the solution be mixed with a sufficient quantity of acid and heated, the binoxide of nitrogen is very readily absorbed, and after the completion of the action, the liquid is found to contain a nitroprusside. Hydroferrocyanic acid is first converted by binoxide of nitrogen into hydroferri-cyanic acid, and the latter then passes into hydronitroprussic acid,

Nitroprussides.

(1) Gmelin's Handb. d. Chem., 4. ed., IV, 370.

Nitroprus-  
sides.

whilst the liquid acquires a red colour with continual evolution of gas. Playfair observes that in this reaction nitric acid is invariably produced, and even when the acid was prepared with washed binocide of nitrogen, and the solution was saturated by an alkaline carbonate, it gave crystals of a nitrate. From this experiment Playfair has arrived at a simple method of preparing nitroprussides; but in order to avoid needless repetition, we shall communicate his process in our description of nitroprusside of sodium. Ferricyanide of potassium is equally well adapted as ferrocyanide of potassium for preparing the nitroprussides.

The nitroprussides have collectively such remarkable properties that they are not easily to be confounded with other cyanogen-compounds. Most of the salts are ruby-red, and dissolve with the same colour in water; the aqueous solutions are not precipitated by alcohol; the soluble salts crystallise with facility; the copper-, nickel-, cobalt-, iron-, zinc-, and silver-compounds are almost perfectly insoluble. As an expression of the constitution of the nitroprussides of the metals, Playfair adduces the complicated formula  $\text{Fe}_5\text{C}_{24}\text{N}_{15}\text{O}_3$ ,  $5 \text{ M} = \text{Fe}_5\text{Cy}_{12}\text{N}_3\text{O}_3$ ,  $5 \text{ M}$ . The far simpler formula  $\text{Fe}_2\text{Cy}_5\text{NO}$ ,  $2 \text{ M}$ , which Playfair himself considers by no means improbable, requires about  $\frac{1}{4}$ th more carbon. According to the two formulae,  $\frac{1}{8}$ th of the cyanogen is replaced by protoxide of nitrogen; this view assumes that the binocide of nitrogen, which plays so important a part in the formation of the nitroprussides, is reduced to the state of protoxide of nitrogen in this process. The analytical investigation presents many difficulties, in consequence of the facility of decomposition and the power this class of cyanogen-compounds possesses of dissolving small quantities of other cyanides, and crystallising therewith without change of form—a power which appears also to be possessed by the platino-cyanogen-compounds of Quadrat. For these reasons also uncertainty attaches to the numbers obtained, and consequently to the formulæ which are deduced from them(1).

*Hydronitroprussic acid* is obtained by decomposing the silver- or barium-compound by hydrochloric or sulphuric acid. Or it may be prepared of a less degree of purity as a strongly-acid, dark-red liquid, by precipitating the potassium-compound by an alcoholic solution of tartaric acid. The liquid, however, soon decomposes with separation of sesquioxide of iron, formation of hydrocyanic acid, and a soluble iron-salt, the presence of which may readily be proved by ferrocyanide of potassium. When evaporated *in vacuo*, this solution affords deliquescent crystals of the acid, which, however, are never perfectly pure. The crystals are of a dark-red colour, they are soluble in water,

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(1) If a solution of nitroprusside of barium be treated with protoxide of mercury, a portion of the nitrogen of the compound is converted into nitric acid—an observation which appears to be in favour of a higher oxide of nitrogen than the protoxide.

alcohol, and ether; the aqueous solution is decomposed at the boiling temperature. The facility with which the crystals deliquesce and are decomposed prevented an accurate determination of their composition; the numbers, however, which have been obtained agree most nearly with the formula  $\text{Fe}_5\text{Cy}_{12}(\text{NO})_3, 5 \text{H} + 6 \text{HO}$ .

Nitroprussides.

*Nitroprusside of sodium* is most readily obtained in the crystalline form; it is either prepared by the direct process, or by the decomposition of nitroprusside of copper or of iron, by caustic soda, an excess of the latter being carefully avoided. 5 equivalents of commercial nitric acid, previously diluted with an equal volume of water, are poured at once over 2 equivalents of the pulverised yellow prussiate of potassa. The salt dissolves to a coffee-coloured liquid, with evolution of the above-mentioned gaseous products; the solution contains ferricyanide of potassium, nitroprusside of potassium, and nitrate of potassa. The solution is digested in a water-bath until a salt of protoxide of iron is no longer precipitated of a blue- but of a slate-colour. On cooling, nitrate of potassa is deposited, and, if less nitric acid has been employed, also *oxamide*. The mother-liquor in the cold is neutralised with carbonate of soda, heated to ebullition, the green or brown precipitate which is formed is separated by filtration, and the ruby-coloured liquid is evaporated to crystallisation. At first a deposit takes place of nitrate of potassa and soda, but on farther evaporation, prismatic crystals separate from the hot solution; these are taken out, and subjected alone to re-crystallisation. The salt may be obtained of still greater purity by precipitating the red solution with sulphate of protoxide of copper, digesting the washed precipitate with caustic soda, carefully avoiding an excess, and evaporating the filtrate to crystallisation. Nitroprusside of sodium forms ruby-coloured crystals, resembling those of ferrocyanide of potassium, and belonging to the rhombic system. According to Miller's determination, the following planes are prevailing,  $\infty \text{P} . \infty \bar{\text{P}} \infty . \infty \check{\text{P}} \infty . \bar{\text{P}} \infty . \text{P} \infty (\infty \text{P} : \infty \text{P} = 105^\circ 17'; \check{\text{P}} \infty : \bar{\text{P}} \infty$  in the brachy-diagonal principal section  $= 136^\circ 32'; \bar{\text{P}} \infty : \bar{\text{P}} \infty$  in the macro-diagonal principal section  $= 124^\circ 52'$ ). This salt is permanent in the air, soluble in  $2\frac{1}{4}$  parts of water at the temperature of  $16^\circ$ , more soluble in hot water, and loses nothing in weight at  $100^\circ$ . From numerous analyses of salts, prepared by different methods, Playfair has calculated the formula  $\text{Fe}_5\text{Cy}_{12}(\text{NO})_3, 5 \text{Na} + 10 \text{HO}$ .—*Nitroprusside of potassium* is obtained in exactly the same manner as the sodium-compound. It is very readily soluble, and hence difficult to crystallise; the crystals belong to the monoclinometric system, with the prevailing planes  $\infty \text{P} . (\infty \text{P} \infty) . -\text{P} . -\text{P} \infty . (\frac{1}{2} \text{P} \infty); \infty \text{P} : (\infty \text{P} \infty) = 130^\circ 14'; -\text{P} : (\infty \text{P} \infty) = 125^\circ 55'; -\text{P} \infty$  to the principal axis  $= 57^\circ 56'$ . It is soluble in an equal weight of water

Nitroprussides.

at a temperature of  $16^{\circ}$ ; when exposed to the light, it acquires a greenish colour, and its solution, when kept for a long time, is partially decomposed. The analysis of the salt, dried at  $100^{\circ}$ , approached nearest to the formula  $\text{Fe}_5\text{Cy}_{12}(\text{NO})_3, 5 \text{ K} + 3 \text{ HO}$ . The crystals when dried in a water-bath, lose 11.7 per cent of water.—The aqueous solution of this salt, when mixed with double its volume of alcohol, deposits, on addition of a caustic alkali, a yellow precipitate, slightly soluble in alcohol, readily soluble in water, and which is decomposed by acids into a salt of potassa and nitroprusside of potassium. Analysis, from which only approximative results could be obtained, gave for this compound the formula  $\text{Fe}_5\text{Cy}_{12}(\text{NO})_3, 5 \text{ K} + 4 \text{ KO} + 8 \text{ HO}$ . Playfair believes it probable that 5 equivalents of potassa are present.—*Nitroprusside of ammonium* is very readily decomposed, and hence could not be prepared perfectly pure. On bringing together an excess of nitroprusside of iron and ammonia, a red solution is formed with evolution of nitrogen, and which crystallises with difficulty under the air-pump. When heated, the solution deposits Prussian blue, and then yields dark-red rhombic crystals ( $\infty \text{ P} . \infty \bar{\text{P}} \infty . \bar{\text{P}} \infty . 0 \text{ P} ; \infty \text{ P} : \infty \text{ P} = 91^{\circ} 56' ; \bar{\text{P}} \infty : \bar{\text{P}} \infty$  in the macrodiagonal principal section  $= 69^{\circ} 45'$ ) of a somewhat changed salt, whose analysis led approximatively to the formula  $\text{Fe}_5\text{Cy}_{12}(\text{NO})_3, 5 \text{ NH}_4 + 2\frac{1}{2} \text{ HO}$ .—*Nitroprusside of barium* is obtained by decomposing the copper-compound by baryta-water, taking great care to avoid an excess of the latter. Under the air-pump it separates in dark-red square-prismatic crystals, which are readily soluble in water ( $\text{P} . 0 \text{ P} . \infty \text{ P} \infty ; \text{P} : \text{P}$  in the terminal edges  $= 120^{\circ} 30' ; \text{P} : 0 \text{ P} = 135^{\circ} 25'$ ). The analysis of the salt dried at  $100^{\circ}$  agreed better with the simple formula  $\text{Fe}_2\text{Cy}_3\text{NO}, 2 \text{ Ba} + 6 \text{ HO}$  than with the formula corresponding to the foregoing salts,  $\text{Fe}_5\text{Cy}_{12}(\text{NO})_3, 5 \text{ Ba} + \text{HO}$ . At  $100^{\circ}$  this compound loses from 14.9 to 15.2 per cent of water. If the solution of nitroprusside of barium be heated to ebullition, a brown powder containing iron and barium is separated, and the filtrate yields, on evaporation, crystals of the same form as the unaltered salt but of variable composition.—*Nitroprusside of calcium* is obtained by decomposing the copper- or iron-compound with milk of lime, avoiding an excess of the latter. This salt very readily decomposes with separation of Prussian blue. The crystals are monoclinometric,  $\infty \text{ P} . \infty \text{ P} \infty . 0 \text{ P} ; \infty \text{ P} \infty : 0 \text{ P} = 82^{\circ} ; \infty \text{ P} : \infty \text{ P}$  in the orthodiagonal principal section  $= 140^{\circ}$ . They dissolve with facility in water, and lose at  $100^{\circ}$  17.85 per cent of their weight. In consequence of the readiness with which the salt decomposes, analysis gave only approximative numbers, and led to the formula  $\text{Fe}_5\text{Cy}_{12}(\text{NO})_3, 5 \text{ Ca} + 5 \text{ HO}$ ; the crystallised salt contained moreover 15 eqivs. of water.—Soluble nitroprussides give with nitrate of silver

a reddish-white precipitate which is readily decomposed with hydrochloric acid or caustic alkalis. The composition of the compound dried at  $100^{\circ}$  agrees with the formula  $\text{Fe}_5\text{Cy}_{12}(\text{NO})_3$ ,  $5 \text{ Ag} + 2 \text{ HO}$ . Its solution in ammonia deposits, on standing, brilliant crystals of a compound of the silver-salt with ammonia, which decomposes readily.—By mixing a soluble copper-salt with a nitroprusside we obtain a pale-green precipitate, which in the light acquires a slate-colour; the precipitate is insoluble in water and in alcohol, and is easily decomposed by caustic alkalis with formation of a soluble nitroprusside of the metal. On this decomposition depends one of the best methods for the preparation of the soluble salts in a state of purity. The copper-compound dried at  $100^{\circ}$  has the formula  $\text{Fe}_5\text{Cy}_{12}(\text{NO})_3$ ,  $5 \text{ Cu} + \text{HO}(1)$ .—Salts of protoxide of iron produce, with soluble nitroprussides of the metals, a salmon-coloured precipitate of the formula  $\text{Fe}_5\text{Cy}_{12}(\text{NO})_3$ ,  $5 \text{ Fe} + 8 \text{ HO}$  when dried at  $100^{\circ}$ .—Salts of sesquioxide of iron are not precipitated.—Salts of zinc give a pale reddish precipitate whose composition is expressed by the formula  $\text{Fe}_5\text{Cy}_{12}(\text{NO})_3$ ,  $\text{Zn} + 2 \text{ HO}$ .—Neutral salts of protoxide of lead, protoxide of mercury, and of the oxides of tin, give no precipitate; but basic lead-salts are precipitated white, salts of protoxide of nickel dirty-white, and salts of protoxide of cobalt of a flesh-colour.—Caustic alkalis transform the red colour of the nitroprussides of the metals into orange; and by ebullition therewith the latter are decomposed into nitrogen, sesquioxide of iron, ferrocyanide of the metal, and a nitrite. To represent this decomposition of the nitroprusside of sodium, Playfair adduces the equation:  $2 [\text{Fe}_5\text{Cy}_{12}(\text{NO})_3, 5 \text{ Na}] + 9 \text{ NaO} = 8 (\text{FeCy}_3, 2 \text{ Na}) + 3 (\text{NaO}, \text{NO}_3) + \text{Fe}_2\text{O}_3 + 3 \text{ N}$ .—Excess of ammonia, even in the cold, gives rise to the evolution of nitrogen, whilst a black, uncrystallisable substance remains. The most characteristic metamorphosis of the nitroprussides is produced by soluble metallic sulphides. If a solution of a nitroprusside be brought into contact with only a very small quantity of a sulphide of an alkaline metal, a magnificent purple-red or blue colour is immediately formed, which is so exceedingly intense that Playfair himself considers it the most delicate means of detecting the presence of a soluble metallic sulphide. In an aqueous solution the colour is only very transitory; if alcoholic solutions of nitroprusside of sodium and of protosulphide of sodium be mixed together the purple-coloured compound precipitates in oily drops which *in vacuo* generally dry to a green powder. This is a mixture of the purple-compound and its

Nitroprussides.

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(1) We may add that the copper-compound dissolves easily in neutral oxalate of potassa, and that oxalate of copper-potassa crystallises from the green solution.



Nitroprus-  
sides.

products of decomposition. Playfair examined the composition of a specimen of the dried blue compound which had suffered the least possible change, and found for it approximatively the formula  $\text{Fe}_5\text{Cy}_{12}\text{N}_3\text{O}_3, 5\text{Na} + 3\text{NaS} + 6\text{HO}$ . The blue compound which had not yet undergone any alteration was precipitated of the same blue colour by salts of protoxide of iron, yellowish-brown by lead-salts, and brown by salts of copper. When dissolved in water, its purple-blue colour quickly passes into red, and then salts of lead produce a red precipitate. The red solution in like manner soon decomposes with deposition of sesquioxide of iron and sulphur. The supernatant liquid contains a ferrocyanide, a sulphocyanide, and a nitrite, while at the same time there are evolved, as products of the transformation, nitrogen, hydrocyanic acid, and at the boiling temperature also ammonia. Playfair expresses this decomposition by the equation  $2(\text{Fe}_5\text{Cy}_{12}\text{N}_3\text{O}_3, 5\text{Na} + 3\text{NaS}) + 2\text{HO} = 7(\text{FeCy}_3, 2\text{Na}) + (\text{CyS}_2, \text{Na}) + (\text{NaO}, \text{NO}_3) + \text{Fe}_3\text{O}_4 + \text{S}_4 + 2\text{HCy} + 2\text{N}$ . The evolution of ammonia he considers to be the result of a secondary action due to the conversion of protoxide of iron into sesquioxide at the expense of the elements of water, whose hydrogen unites with the nitrogen and forms ammonia. No protoxide of iron could be detected in the solution. Starting from the observation of Gregory, that sulphide of nitrogen produces with caustic alkalies a transitory amethyst-colour, which disappears with evolution of ammonia, Playfair likewise considers it probable that the blue compound is  $= \text{Fe}_5\text{Cy}_{12}\text{N}_3\text{S}_3, 5\text{Na} + 3\text{NaO} + 6\text{HO}$ . If hydrosulphuric acid be passed through an alcoholic solution of nitroprusside of sodium a precipitate gradually appears which consists of sulphur, Prussian blue, and ferrocyanide of sodium; the supernatant brown liquid contains a peculiar sulphur-compound, the nature of which has not yet been investigated.—Chlorine or sulphurous acid induce no decomposition; heated with concentrated sulphuric acid the same transitory purple colour is produced as by soluble metallic sulphides. Prussian blue dissolves in excess of nitroprusside of sodium, forming a beautiful blue liquid; but with a larger quantity of Prussian blue it forms an insoluble double compound which yields to boiling water nitroprusside of sodium.

With reference to the formation of hydronitroprussic acid from hydroferricyanic acid by the action of binoxide of nitrogen ( $\text{Fe}_2\text{Cy}_6, \text{H}_3 + \text{NO}_2 = \text{Fe}_2\text{Cy}_5\text{NO}_2, \text{H}_2 + \text{HCy}$ ) Gerhardt(1) considers the formula  $\text{Fe}_2\text{Cy}_5\text{NO}_2, 2\text{M}$  as the true expression of the composition of the nitroprussides. The following comparative table of the numbers obtained by Playfair, with those calculated according to his own and

Gerhardt's formula, exhibits indeed, an accordance in favour of the latter :— Nitroprussides.

	Carbon.	Nitrogen.	Hydrogen	Iron.	Basic Metal.
Crystallised Acid : found . . .	24.7 to 24.9	36.7	1.7 to 1.8	23.7 to 23.9	—
$\text{Fe}_2\text{Cy}_5\text{NO}_2, \text{H}_2 + 2 \text{HO}$ (Gerh.) .	25.4	35.6	1.6	23.7	—
$\text{Fe}_5\text{Cy}_{12}(\text{NO})_3, \text{H}_5 + 6\text{HO}$ (Playf.)	24.9	36.3	1.9	24.2	—
Ammonium-salt : found . . .	22.6	45.9	3.2	22.1	—
$\text{Fe}_2\text{Cy}_5\text{NO}_2, 2 \text{NH}_4$ (Gerh.) . . .	23.8	44.4	3.1	22.2	—
$\text{Fe}_5\text{Cy}_{12}(\text{NO})_3, 5 \text{NH}_4, 2 \text{HO}$ (Playf.)	23.0	44.7	3.5	22.3	—
Potassium-salt : found . . .	19.6	—	0.7	19.05	26.4
$\text{Fe}_2\text{Cy}_5\text{NO}_2, 2 \text{K}$ (Gerh.) . . .	20.4	—	—	19.0	26.5
$\text{Fe}_5\text{Cy}_{12}(\text{NO})_3, 5 \text{K}, 3 \text{HO}$ (Playf.)	19.4	—	0.4	18.9	26.3
Sodium-salt : found . . .	19.5 to 20.4	27.8 to 28.8	1.3 to 1.6	19.3 to 19.9	15.2 to 16.3
$\text{Fe}_2\text{Cy}_5\text{NO}_2, 2\text{Na} + 4 \text{HO}$ (Gerh.) .	20.1	28.1	1.3	18.8	15.4
$\text{Fe}_5\text{Cy}_{12}(\text{NO})_3, 5 \text{Na} + 10 \text{HO}$ (Playf.)	19.9	29.0	1.3	19.3	16.0
Barium-salt : found . . .	14.9 to 15.1	—	1.2 to 1.5	14.0 to 14.1	34.4 to 34.8
$\text{Fe}_2\text{Cy}_5\text{NO}_2, 2 \text{Ba} + 4 \text{HO}$ (Gerh.) .	15.4	—	1.1	14.4	35.0
$\text{Fe}_2\text{Cy}_5\text{NO}_2, 2 \text{Ba} + 6 \text{HO}$ (Playf.) .	15.0	—	1.5	14.0	34.3
$\text{Fe}_5\text{Cy}_{12}(\text{NO})_3, 5 \text{Ba} + 15 \text{HO}$ (Playf.)	14.4	—	1.5	14.0	34.4
Silver-salt : found . . .	13.3	19.3	0.25	13.0	50.1
$\text{Fe}_2\text{Cy}_5\text{NO}_2, 2 \text{Ag}$ (Gerh.) . . .	13.8	19.4	—	12.9	50.0
$\text{Fe}_5\text{Cy}_{12}(\text{NO})_3, 5 \text{Ag} + 2 \text{HO}$ (Playf.)	13.4	19.5	0.2	13.0	50.1

If the formula proposed by Gerhardt should prove correct, then the volatile products, in addition to hydrocyanic acid, observed by Playfair—namely, cyanogen, cyanic acid, carbonic acid, and nitrogen—must be formed by the secondary action of the nitric acid.

**Platinocyanides.**—Quadrat has continued (1) his investigation regarding the platinocyanides, already mentioned in the Annual Report for 1847-8, I, 369. He believes that the platinocyanides described as being composed according to the formula  $\text{Pt}_5\text{M}_6\text{Cy}_{11}$  do actually exist, and moreover he considers it probable that other series of platinocyanides may be produced. — *Platinocyanide of potassium*,  $\text{Pt}_5\text{K}_6\text{Cy}_{11}$ , crystallises with facility when an excess of cyanide of potassium is employed, and by repeated recrystallisation is obtained in a state of purity; if, however, it is boiled for a long time with water, the proportion of platinum, in the compound obtained by several recrystallisations, rises from 49.05 to 51.65 per cent, the latter quantity agreeing with the formula  $\text{PtKC}_2$ . Quadrat mentions that the statements he made on a former occasion to the effect that a sulpho-

(1) Ann. Ch. Pharm. LXX, 300; Wien. Acad. Ber. June and July 10, 1849.

Platinocyanides.

cyanogen-compound exists in hydroplatinocyanic acid, prepared from platinocyanide of copper by means of hydrosulphuric acid, and likewise in the salts prepared therewith, have no relation whatever to the salts which he first described, since they are free from sulphur.

Quadrat, in the first place, describes some salts belonging to the series of the simple platinocyanides which were all prepared from *platinocyanide of copper*  $\text{PtCuCy}_2$ ; the latter differs from the compound  $\text{Pt}_5\text{Cu}_6\text{Cy}_{11}$  only in composition; it forms two crystallisable blue compounds with ammonia.—*Platinocyanide of sodium*, having the composition  $\text{PtNaCy}_2$  when dried at  $280^\circ$ , is obtained by boiling platinocyanide of copper with an excess of carbonate of soda. It forms large, colourless monoclinometric crystals which are soluble in water and in alcohol; with nitrate of suboxide of mercury it frequently produces a beautiful crimson precipitate.—*Platinocyanide of calcium* is formed by boiling the copper-compound with caustic lime; it crystallises in delicate monoclinometric needles which exhibit the same trichroism as the following salt. At  $180^\circ$  it loses 20.38 per cent of water, and is then represented by the formula  $\text{PtCaCy}_2$ . With chloride of calcium it produces a crystallisable compound.—*Platinocyanide of barium* crystallises in six-sided monoclinometric prisms with terminal planes; it is of a deep lemon-yellow colour, the crystals exhibiting upon the planes of the prisms purplish-blue variations, and a light-yellow colour in the direction of the axes. It contains 15.3 per cent of water, and when dried at  $180^\circ$  is expressed by the formula  $\text{PtBaCy}_2$ .—*Platinocyanide of magnesium*, which has the formula  $\text{PtMgCy}_2$  when dried at  $280^\circ$ , has the same form as the salt  $\text{Pt}_5\text{Mg}_6\text{Cy}_{11}$ . It is obtained perfectly colourless from a concentrated alcoholic solution; by evaporating the alcohol, however, the crystals become at first sulphur-yellow, then flesh-coloured, whilst from a hot saturated aqueous solution the compound separates in blood-red crystals.—Platinohydrocyanic acid acquires with ammonia a yellow, and finally, with an excess, a white colour, but the white compound, when exposed to the air, loses ammonia and again becomes yellow. A similar deportment is exhibited by the prismatic crystals that are obtained by evaporating platinocyanide of potassium with sulphate of ammonia and exhausting the dried mass by alcohol.—On the other hand Gerhardt(1) has repeated the analysis of platinocyanide of potassium prepared by the method of Quadrat, and, like Laurent(2), arrived at the formula  $\text{KCy}$ ,  $\text{PtCy} + 3\text{HO}$ .

**Acids and Collateral Matters. Malic Acid.**—It is stated by H. Schulze(3) that on crystallising a mixture of solutions of sulphate of copper and malate of ammonia, an accidental excess of the former salt

(1) Laur. and Gerh. C. R. 1850, 146.

(2) Comp. Annual Report for 1847-8, Vol. I, 369.

(3) Arch. Pharm. [2] LVII, 273.

first separates, and then a double-salt of malate of copper and sulphate of ammonia, which forms beautiful grass-green, spear-shaped crystals which are not altered by exposure to the air.

Succinic  
acid.

**Succinic Acid.**—Piria(1) has shown that crystallised asparagin, which contains the elements of malic acid and ammonia, gives rise to the formation of succinic acid. Dessaignes(2) has now found that malate of lime, when placed with water in an open vessel and exposed to the air for several months, gradually yields a slimy substance, together with crystals of hydrated carbonate of lime and fine prisms of succinic acid.—Liebig(3) by investigating this decomposition of malate of lime has arrived at the following results. A mixture of 1 part of malate of lime, 5 or 6 of water, and a quantity of beer-yeast amounting to  $\frac{1}{10}$ th part of the volume of water, when put into a warm place, soon gives rise to a lively evolution of pure carbonic acid. The suspended malate of lime becomes, after some days, more granular; the grains, which are continually increasing in size, consist of a compound of succinate and carbonate of lime, whilst acetate of lime is found in the supernatant liquid. The decomposition is also rapidly induced by employing in the place of yeast putrid fibrin, or rotten cheese; when yeast is employed hydrogen is evolved in the last stage of the process. Three pounds of crude malate of lime, prepared from the juice of mountain-ash berries according to the method of Liebig,(4) is made into a paste with 10 pounds of water at a temperature of  $40^{\circ}$ . This is then mixed with 4 ounces of putrid cheese, previously rubbed up with water, and exposed at a temperature of from  $30^{\circ}$  to  $40^{\circ}$ , when fermentation speedily commences, and after some days ceases. The compound produced of malate and carbonate of lime is mixed with dilute sulphuric acid until effervescence ceases; a similar quantity of dilute sulphuric acid is then added, and the mixture heated to ebullition till the granular property of the solid salt has disappeared; it is then filtered through a linen bag. The liquid contains bisuccinate of lime and succinic acid; it is now evaporated until a crystalline pellicle forms upon the surface, and concentrated sulphuric acid added until sulphate of lime ceases to be precipitated. The filtered liquid, diluted with water, is evaporated to crystallisation, and the succinic acid purified by treatment with a little animal charcoal and re-crystallisation. From 3 pounds of malate of lime Liebig obtained from 15 to 16 ounces of brilliantly white succinic acid.—Liebig, moreover, has subsequently found that the more slowly and gently the ferment-

(1) Comp. Annual Report for 1847-8, II, 114.

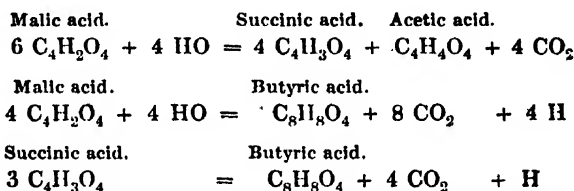
(2) Ann. Ch. Phys. [3] XXV, 253; Compt. Rend. XXVIII, 16; Instit. 1849, 1; J. Pharm. [3] XV, 264; Ann. Ch. Pharm. LXX, 102; J. Pr. Chem. XLVI, 380. Dessaignes found asparagin in the young shoots of all the Leguminosæ.

(3) Ann. Ch. Pharm. LXX, 104.

(4) Ann. Ch. Pharm. XXXVIII, 259.

Succinic  
acid.

tation is accomplished, the larger is the quantity of succinic acid obtained. If an evolution of hydrogen takes place, another mode of fermentation ensues, in which either no succinic acid is formed, or in which that which is produced undergoes again decomposition. 125 cubic centimeters of beer-yeast, 1 pound of dried malate of lime, and 6 pounds of water are good proportions for the preparation of succinic acid. When 19 pounds of malate of lime were allowed to ferment with double the usual quantity of cheese, fermentation took place with great violence after a period of seven days; nearly half the evolved gas consisted of hydrogen, and not more than 1 pound of succinic acid was obtained. In the place of acetic acid the mother-liquor contained from 24 to 30 ounces of butyric acid which was contaminated with acetic acid; by distilling the mother-liquor containing the lime-salts, an oily ethereal colourless fermentoleum was obtained, which was soluble in water, and could be separated therefrom by chloride of calcium or carbonate of potassa(1). The decomposition which takes place is explained, according to Liebig, by the following formulæ:—



According to Vorwerk(2), the black carbonaceous mass which is formed in the preparation of ether, contains succinic acid, which may be obtained therefrom, by a process similar to that adapted for preparing the acid from amber(?).

**Tartaric Acid.**—In order to prepare carbonate of potassa from bitartrate of potassa, Wittstein(3) recommends to recover a portion of the acid in the following manner; 30 parts of pulverised tartar, 6 parts of hydrate of lime, and 90 parts of water, are digested at a gentle heat for some days; the tartrate of lime formed is decomposed by sulphuric acid, and the liquid filtered from the sulphate of lime, which contains only traces of lime, employed in preparing neutral tartrate of potassa or carbonate of potassa.

Wackenroder(4) has communicated investigations regarding the composition of boro-tartrate of potassa. The concentrated solution of

(1) The formation of this fermentoleum has been also subsequently observed by Rump and Retschy (Repert. Pharm. [3] VI, 82).

(2) Jahrb. Pr. Pharm. XIX, 265.

(3) Repert. Pharm. [3] II, 313.

(4) Arch. Pharm. [2] LVIII, 4.

Tartaric  
acid.

1 part of borax and 3 parts of purified bitartrate of potassa, still containing a little lime, slowly deposited a fine crystalline powder, in which were found 19.2 per cent of potassa, 4.3 lime, 1.0 soda, 61.3 tartaric acid (in the hypothetical anhydrous state), 2.0 boracic acid, and 12.2 water. In the boro-tartrate of potassa, prepared according to the above directions,  $\frac{1}{3}$ th of the bitartrate of potassa is in excess. It is merely mixed with the true double-salt, and separates gradually from the solution. As the most convenient mode of preparing boro-tartrate of potassa, Wackenroder recommends to dissolve, at a gentle heat, 24 parts (2 equivalents) of crystallised borax with 59 parts (5 equivalents) of dry pulverised bitartrate of potassa, previously purified as much as possible by hydrochloric acid, in 180 parts of water, then to filter and evaporate. When dried at from  $50^{\circ}$  to  $130^{\circ}$ , until it no longer decreases in weight, the product remains perfectly stable. Also the salt which is prepared from 1 part of borax and 3 parts of bitartrate of potassa, is liable to change or to deliquesce only when imperfectly dried. When the above salt is dried as much as possible, a quantity of water escapes, which corresponds to a transformation of 4 equivalents of tartaric acid into  $C_8H_2O_8$ .

**Racemic Acid.**—With reference to the formation of racemic acid, Kestner, its discoverer, has communicated the following facts(1). Racemic acid was prepared in Thann, in the years 1822 and 1824; at that period the bitartrate of potassa was saturated with carbonate of lime, and the decomposition was completed by chloride of calcium; the bitartrate of lime was decomposed by a large excess of sulphuric acid, the solution of tartaric acid evaporated over an open fire, and bleached by chlorine. At a subsequent period, the bitartrate of potassa was decomposed by caustic lime, only a slight excess of sulphuric acid was added, and the bleaching by chlorine discontinued; from this time racemic acid was no longer obtained.—Pelouze(2) has communicated a note of White (of Glasgow?), who in 1829 obtained, in manufacturing tartaric acid on a large scale, crystals which differed from those of tartaric acid, and which were probably racemic acid; the bitartrate he then employed was imported from Naples, Sicily, and Oporto. Kestner now mentions that the bitartrate of potassa, which he employed in 1822 and 1824, likewise came from Italy.

Pasteur(3) has published the completion of his investigations on

(1) Compt. Rend. XXIX, 526.

(2) Compt. Rend. XXIX, 557.

(3) Ann. Ch. Phys. [3] XXVIII, 56; Compt. Rend. XXVIII, 477; XXIX, 297 (in abstr.); Instit. 1849, 124, 298; Dumas, Regnault, Balard and Biot's Report, Compt. Rend. XXIX, 433; Instit. 1849, 337, Biot's Optical Experiments, (which confirm Pasteur's statements), Ann. Ch. Phys. [3] XXVIII, 99, comp. also this Report, 127.

Racemic  
acid.

racemic acid, some of which have already been detailed in the Annual Report for 1847 and 1848, Vol. I, 22. He states that racemic acid consists of two acids, which, according to their action upon the plane of polarisation, he distinguishes as *acide dextroracémique*, which is identical with tartaric acid, and *acide lévoraçémique*. We will adopt these expressions, but retain the term *racemic acid* for the compound of the two. By combining racemic acid with the majority of bases, crystallised salts are formed, the crystals of which invariably contain racemic acid; it is only in the preparation of racemate of soda-ammonia, and racemate of soda-potassa, that racemic acid is split into dextroracemic and levoracemic acids, whose salts separately crystallise.—By slowly crystallising a solution of racemate of soda-ammonia two varieties of crystals are produced, and may readily be distinguished by their form, viz., as the image and the reflection of the image, or as dextral and leval. The difference between them will become at once evident, if we imagine a rhombic prism, with a right terminal plane, with one acute edge of the prism turned towards the observer. If the edges between the prism and the right terminal plane are truncated by hemihedral planes at the top—in front towards the right, and on the back towards the left, and at the bottom—in front towards the left, and on the back towards the right, the prism can never assume such a position as to exhibit these planes of truncation at the top—in front, towards the left, &c., provided the more acute edges of the prism are turned towards the observer. On the other hand, a prism which exhibits in the same position hemihedral planes of truncation at the top—in front towards the left, and at the back towards the right, and at the bottom—in front towards the right, and at the back towards the left—is the reflected image of the preceding form. The two kinds of crystals which are deposited by the crystallisation of racemate of soda-ammonia, are distinguished from each other by the small hemihedral planes of truncation, which are reversed in the manner above stated. The crystals exhibit combinations of rhombic prisms, in which the two vertical terminal planes occur, in addition to the horizontal right terminal plane. If we place in front that vertical terminal plane whose edges of combination (in reference to the horizontal terminal plane) are replaced by two small planes, the crystals which exhibit at the top, in front towards the right, together with these small planes, a plane truncating the edge of combination between the prism and the horizontal terminal plane, consist of dextroracemic acid. On the other hand, those which have this plane of truncation at the top, in front, towards the left, consist of levoracemic acid. The sp. gr. of both kinds of crystals is the same and equal to that of tartrate of soda-ammonia, viz., 1.576; they are likewise analogous in chemical composition and in the degree of solubility, 100 grms. of solution containing at 0°

21.2 grms. of crystallised double salt; equally strong solutions of the two salts rotate the plane of polarisation to an equal extent, the one, however, towards the right and the other towards the left. The two kinds of crystals differ in their deportment from racemic acid; a somewhat dilute solution of the crystals containing levoracemic acid forms, on addition of a lime-salt, small lustrous and distinct crystals of levoracemate of lime; a solution of crystals which contain dextroracemic acid (tartaric acid) comports itself in a similar manner; a solution of the two kinds of crystals, however, forms with lime-salts a precipitate of racemate of lime differing essentially in its appearance.—When the two kinds of crystals are picked from each other and are separately recrystallised, each will form only crystals with one kind of the hemihedral planes. If a solution of one of these varieties of crystals is decomposed by a lead- or a baryta-salt, and the precipitate which is formed is decomposed by sulphuric acid, we obtain dextroracemic acid (tartaric acid) or levoracemic acid according to the kind of crystals employed. Both kinds of acid may be obtained in crystals, having the same sp. gr. and solubility and the same composition ( $C_4H_2O_6, HO$ ). The crystalline form and cleavage of the two kinds of crystals is the same, with this difference only, that in the oblique rhombic prism of dextroracemic acid (tartaric acid) hemihedral planes occur on the one side, whilst in levoracemic acid they appear on the other side. Both acids exhibit pyro-electricity, and it was remarked that on cooling the positive electricity was invariably manifested at that side of the crystal on which the hemihedral planes occurred. The two acids rotate the plane of polarisation to an equal extent but in an opposite direction. Pasteur established beyond a doubt the identity of dextroracemic acid with tartaric acid, by an accurate comparison of all their properties. Dextro- and levoracemic acids, which both differ from the true racemic acid, again give rise to the latter when concentrated solutions of the two acids are mixed; in this case a perceptible development of heat is immediately manifested, together with a copious deposition of crystals of racemic acid.—Pasteur, moreover, has investigated various salts of dextro-, as well as of levoracemic acid; these are the neutral ammonia-salt, the neutral potassa-salt, the teroxide of antimony-ammonia-salt, and the potassa-soda-salt. In all these salts the above-mentioned characteristic properties are exhibited, namely, difference from the true racemates, and agreement of the corresponding dextroracemates and levoracemates in relation to external form, with the sole exception that the hemihedral planes have an opposite position, and lastly an equal but opposite rotation of the plane of polarisation. Levoracemate of lime exhibits only holohedric planes of crystallisation, and is therefore not to be distinguished by its form from the dextroracemate (tartrate); it differs, however, from the latter, inasmuch as it yields, when mixed with it, the true racemate of lime which exhibits another deportment.



Lactic acid.

**Lactic Acid.**—Engelhardt(1) has investigated the products of the distillation of lactic acid and of lactate of copper. If highly concentrated lactic acid is distilled from a retort, at a temperature of from  $130^{\circ}$  to  $140^{\circ}$ , an acid, aqueous, somewhat empyreumatic liquid slowly passes over, which is dilute lactic acid; if the distillation ceases, and the retort is then allowed to cool, there remains behind anhydrous lactic acid,  $C_{12}H_{10}O_{10}$ , which has been described by Pelouze(2). The process of dehydration takes place more quickly at from  $180^{\circ}$  to  $200^{\circ}$ , but at this high temperature a larger quantity of unchanged lactic acid distils over; in general lactic acid in the presence of an angular solid body, for instance a platinum wire, may be distilled at  $200^{\circ}$  without decomposition. Anhydrous lactic acid is not altered at a temperature of  $240^{\circ}$ , but at  $250^{\circ}$  the decomposition commences, and goes on rapidly at  $260^{\circ}$ . Carbonic oxide is evolved, which is accompanied, when the temperature is continually maintained at  $260^{\circ}$ , by only 3 to 4 volumes per cent of carbonic acid, but not a trace of a carbohydrogen. In the retort there remains from 1 to 2 per cent of an easily combustible, highly lustrous carbon, whilst in the well-cooled receiver, a yellowish liquid is condensed, which after some time deposits crystals, and moreover contains aldehyde, lactide, citraconic acid, and the ordinary hydrated lactic acid. Lactone and acetone, which Pelouze mentions as occurring among the products of distillation, could not however be detected. If the distillate be agitated with water, aldehyde and hydrated lactic acid are dissolved, while a heavy oil consisting of lactide, citraconic acid, and a portion of hydrated lactic acid separates, which, when placed in contact with water, slowly disappears. The crystalline magma which separates from the distillate is washed with cold absolute alcohol, pressed, and the pure lactide thus obtained recrystallised from the smallest possible quantity of absolute alcohol: the crystals of lactide appear to be similar to those of sulphate of protoxide of iron, and crumble on being dried. Lactide may be slowly sublimed at  $120^{\circ}$ , but at higher temperatures it fuses, and at  $250^{\circ}$  it yields the same products of decomposition as are yielded by anhydrous lactic acid.—Engelhardt has confirmed for lactide the formula  $C_6H_4O_4$ ; the presence of citraconic acid he has proved by the analysis of its baryta-salt. On decomposing 19.5 grms. of anhydrous lactic acid, by heating it at a temperature of  $260^{\circ}$  for a period of eight hours, he obtained 12.2 per cent of aldehyde, 14.9 per cent of lactide, and 1 per cent of carbon; at a higher temperature more aldehyde and less lactide and lactic acid are found amongst the products of distillation. According to the author's observation the decomposition consists

(1) Ann. Ch. Pharm. LXX, 241.

(2) J. Pharm. [3] VII, 1; Berzelius' Jahresber. XXV, 787.

chiefly in the conversion of 1 equivalent of lactide ( $C_6H_4O_2$ ) into 1 equivalent of aldehyde and 2 equivs. of carbonic oxide ( $C_4H_4O_2 + C_2O_2$ ). Dehydrated lactate of copper, when heated to a temperature between  $200^\circ$  and  $210^\circ$ , yields in the first place carbonic acid, aldehyde, and a small portion of hydrated lactic acid which is probably due to some remaining water of crystallisation; in the retort there is left metallic copper and anhydrous lactic acid, which is farther decomposed at from  $250^\circ$  to  $260^\circ$ . Engelhardt recommends the preparation of aldehyde from lactic acid, or a lactate of a feeble base. The salts of the stronger bases, such as the lime-salt, yield other products.

Städeler(1) has remarked that, in the distillation of 1 part of lactate of protoxide of iron, with 4 parts of binoxide of manganese and common salt, and 4 parts of sulphuric acid diluted with double its weight of water, aldehyde chiefly passes over; with 1 part of lactate of protoxide of iron, 10 parts of binoxide of manganese and salt, 10 parts of sulphuric acid, and from 12 to 14 parts of water, aldehyde first distils over, and subsequently chloral, accompanied by another body which is destroyed by hot sulphuric acid(2).

**Camphoric Acid.**—Gerhardt and Lies-Bodart(3) have investigated the decomposition of camphorate of lime by dry distillation. It is advantageous to submit the salt to distillation in small quantities at a time, when a brown oil passes over, which is purified by rectification; it always retains a yellowish colour, and becomes again darker by exposure to the air. This compound, which has received the name of *phorone*, is lighter than water, has the odour of pepper-mint, and boils constantly at  $208^\circ$ . In addition to this there is obtained in this distillation a tarry body, which appears to be a secondary product produced by the decomposition of phorone at a high temperature. The composition of phorone is  $C_9H_7O$  or  $C_{18}H_{14}O_2$ ; the weight of its vapour was found to be  $=4.98$ ; assuming a condensation to 4 volumes, it is calculated at 4.8, for the formula  $C_{18}H_{14}O_2$ . The formation of this body is consequently analogous to that of the acetones of the acids  $C_nH_nO_4$ . Phorone dissolves with a blood-red colour in sulphuric acid, and is, for the most part separated from this solution by water; nitric acid acts thereon with great violence with the formation of a resinous substance. A mixture of potassa and lime when mixed with phorone becomes heated; the mixture may be exposed to a temperature of  $20^\circ$  or  $30^\circ$  above the boiling-point of phorone without any of the

(1) Ann. Ch. Pharm. LXIX, 333; Arch. Pharm. [2] LVIII, 194; Instit. 1849, 150; J. Pharm. [3] XVI, 38.

(2) The lactates yield aldehyde abundantly when distilled with binoxide of manganese, even without the addition of salt.

(3) Laur. and Gerh. C. R. 1849, 385; Compt. Rend. XXIX, 506 (in abstr.); Ann. Ch. Pharm. LXXII, 293.

Camphoric  
acid.

latter distilling over; at  $240^{\circ}$  a colourless oil distils, which is different in appearance from phorone, while a resinous substance remains in combination with the potassa-lime.—Anhydrous phosphoric acid acts violently upon phorone, and gives rise to the formation of cumole ( $C_{18}H_{12}$ ).

**Meconic Acid.**—According to Einbrodt(1), the formula  $3AgO$ ,  $2C_7HO_6$  for the yellow meconate of silver, corresponds better with the results he has obtained in recalculating the analyses of Liebig; the formula of the white silver-salt he writes with Löwig,  $AgO$ ,  $C_7HO_6$ , and that of the free acid  $C_7HO_6 + HO$ .

**Kinic Acid.**—Kremers(2) has investigated the basic kinate of protoxide of copper, prepared by decomposing sulphate of copper with an excess of kinate of baryta, adding baryta-water until the precipitate which is formed ceases to dissolve, and leaving it to crystallise at a moderate heat. He found the composition of the crystals, dried over sulphuric acid, to be  $2CuO$ ,  $C_{14}H_{10}O_{10} + 4HO$ ; and that 4 HO are expelled at  $120^{\circ}$ .

**Kinone.**—In the Annual Report for 1847-8, I, 401, it was mentioned that the formula  $C_3HO$  of kinone, as first determined by Woskresensky, was recognised as the true expression of its composition. More recent investigations, on which we have here to report, have proved that the equivalent of kinone is most correctly expressed by  $C_{12}H_4O_4$ .

Wöhler(3) has again resumed the investigation of the sulphur-compounds of kinone, which he had described at an earlier period(4).—*Brown sulphohydrokinone*, which is formed when a current of hydrosulphuric acid is passed into a solution of kinone, care being taken that a portion of the latter remains unaltered, has the composition  $C_{12}H_5O_4S_2$ ; it was found that its formation is dependent upon the simultaneous production of the green hydrokinone, whose presence does not admit of the compound being obtained in a state of purity. 2 equivs. of kinone and 2 equivs. of hydrosulphuric acid yield 1 equiv. of brown sulphohydrokinone and 1 equiv. of green hydro-

(1) From Bull. der Naturforsch. Gesellsch. in Moskau XXI, 1848, in J. Pr. Chem. XLVI, 284.

(2) Ann. Ch. Pharm. LXXII, 92.

(3) Ann. Ch. Pharm. LXIX, 294; Arch. Pharm. [2] LVIII, 186; Instit. 1849, 148; J. Pharm. [3] XVI, 35. From the earlier statements of Wöhler regarding the compounds of kinone, and from those of Woskresensky, whose formula  $C_{12}H_4O_4$  he confirms, Laurent (Laurent and Gerhardt's C. R. 1849, 190; J. Pr. Chem. XLVII, 153) has endeavoured to deduce formulæ which agree with his own and Gerhardt's views regarding the composition of chemical compounds. The recent investigation of Wöhler, however, appears to render it unnecessary to give here an abstract of Laurent's views. Laurent, for instance, proposes for brown sulphohydrokinone the formula  $C_{12}H_4S_2O_2$ , and for the yellow compound  $C_{12}H_6S_2O_2$ .

(4) Ann. Ch. Pharm. LI, 145; Berzelius' Jahresber. XXV, 827.

kinone ( $C_{12}H_6O_4$ ).—*Yellow sulphohydrokinone*  $C_{12}H_6O_4S$ , is formed when the foregoing compound is suspended in water and exposed to the farther action of hydrosulphuric acid. It is best obtained by saturating an alcoholic solution of kinone with hydrosulphuric acid; the solution first becomes dark-brown, finally bright-yellow and cloudy by the separation of sulphur; it is likewise formed, with deposition of sulphur, when an alcoholic solution of brown sulphohydrokinone is saturated with hydrosulphuric acid. The products of earlier preparations which were investigated had been mixed with sulphur; the pure compound is obtained as a yellowish crystalline mass when the alcoholic solution, filtered from the sulphur, is left to evaporate *in vacuo*. It fuses with partial decomposition even below  $100^\circ$ . Its alcoholic solution produces with acetate of lead a white precipitate, and with solution of kinone, brown sulphohydrokinone with simultaneous formation of green and colourless hydrokinone. In the formation of yellow sulphohydrokinone, 1 equiv. of the brown compound combines with 1 equiv. of hydrosulphuric acid, with the separation of 2 equivs. of sulphur; 2 equivs. of yellow sulphohydrokinone and 1 equiv. of kinone give 1 equiv. of brown sulphohydrokinone, 1 equiv. of colourless, and 1 equiv. of green hydrokinone.—The bodies produced by the action of chlorine upon the above-mentioned compounds, and formerly described as *chloro-sulphokinones*, are very probably nothing more than mixtures.—Colourless hydrokinone,  $C_{12}H_6O_4$ , combines with hydrosulphuric acid in two proportions. *Rhombohedral hydrosulphate of hydrokinone*,  $3 C_{12}H_6O_4 + 2HS$ , separates in small brilliant crystals, when hydrosulphuric acid is passed into a cold saturated solution of colourless hydrokinone; if the liquid be heated during the continued passage of the gas, the crystals again dissolve, and on slowly cooling the solution the compound separates in large colourless rhombohedrons, which must be quickly pressed between folds of bibulous paper and dried *in vacuo*. The crystals are inodorous, and when dry, unalterable, but if they are moistened with water they decompose into hydrosulphuric acid and colourless hydrokinone; the change being rapidly induced if the solution is boiled. A similar department is observed when the crystals are treated with alcohol, or fused. *Prismatic hydrosulphate of hydrokinone*,  $2 C_{12}H_6O_4 + HS$ , is formed when hydrosulphuric acid is passed into a saturated solution of colourless hydrokinone at a temperature of about  $40^\circ$ ; it forms very long colourless prisms. It is probable that a compound,  $C_{12}H_6O_4 + HS$ , likewise exists.—A compound of hydrokinone with acetate of lead,  $2 (PbO, C_4H_3O_3) + C_{12}H_6O_4 + 3 HO$ , or perhaps more correctly  $(PbO, C_4H_3O_3 + C_{12}H_6O_4) + (PbO, C_4H_3O_3 + 3 HO)$ , was accidentally observed in the analysis of hydrosulphate of hydrokinone by means of a solution of acetate of lead, during which it immediately commenced to crystallise out. It is directly obtained

Kinone.

when colourless hydrokinone is dissolved in a moderately concentrated and warm solution of acetate of lead; on the cooling of this solution it separates in the crystalline state. It forms oblique rhombic prisms difficultly soluble in cold, and readily soluble in hot water without decomposition; cold alcohol dissolves scarcely a trace, but in hot alcohol, and also in ether, it appears to be decomposed. At  $100^{\circ}$  the crystals acquire a milk-white colour with loss of water; and when heated to temperatures above  $180^{\circ}$  the crystals fuse and suffer decomposition. By mixing a concentrated solution of this compound with a solution of kinone, pure green hydrokinone separates.

Städeler(1) has published investigations upon the chlorinated products of the decomposition of kinic acid. If this acid be submitted to distillation with a chlorine-mixture, an acid liquid and a crystalline sublimate are obtained. The liquid contains formic acid and an oily body which is a general product of the decomposition of organic bodies by chlorine, and will be described by Städeler on a future occasion. The crystalline sublimate is a mixture of four compounds, which may be considered as kinone, in which 1, 2, 3 or 4 equivalents of hydrogen are replaced by chlorine. Städeler designates the three first bodies as chlorokinone, dichlorokinone, and trichlorokinone, the last being the chloranile discovered by Erdmann. Similarly to kinone, all these compounds are capable of assuming hydrogen, and forming compounds therewith analogous to hydrokinone. —The largest quantity of solid products appears to be obtained by employing 1 part of kinate of copper, 4 parts of a mixture of 2 of binoxide of manganese and 3 of common salt, with 4 parts of sulphuric acid, previously diluted with 3 times its volume of water; it is not advisable to employ in one operation more than from 20 to 25 grms. of the kinate. The mixture swells up and evolves carbonic acid, and in the commencement of the operation also a small portion of chlorine. The ebullition is continued rapidly, and the vapours are passed through a long glass tube, which is cooled sufficiently to prevent the products from becoming hot in the receiver in which they are collected. By moderately cooling the upper part of the condensing tube, it is possible to condense almost entirely the chloranile which is volatile with difficulty, and may be thus separated from the other solid products. The latter compounds are collected upon a filter, washed with cold water, and dried; the dried and divided mass is repeatedly digested with small quantities of absolute alcohol, until the latter ceases to become intensely coloured; the alcohol leaves dichlorokinone with small quantities of trichlorokinone and

(1) Ann. Ch. Pharm. LXIX, 300; Arch. Pharm. [2] LVIII, 188; Instit. 1849, 149; J. Pharm. [3] XVI, 389.

chloranile, and dissolves chlorokinone and trichlorokinone which may be separated from this solution by water.

Kinone.

*Chlorokinone*,  $C_{12}H_3ClO_4$ , could not be obtained entirely free from trichlorokinone. The yellow precipitate produced by water in the above-mentioned alcoholic solution is a mixture of delicate needles (chlorokinone) and plates (trichlorokinone). From a solution of the mixture in a small quantity of boiling alcohol, a portion of the trichlorokinone first crystallises in yellow plates, and only at a later period yellow needles are deposited; but if the liquid at this point of the process is precipitated with water, and the precipitate repeatedly submitted to the same treatment, crystals of trichlorokinone are still invariably deposited with the other compound. Städeler considers the following properties of chlorokinone established with accuracy. It crystallises in delicate yellow needles which fuse at the boiling temperature of water; it imparts a purple colour to organic substances; it has a peculiar aromatic odour, and pungent and burning taste; it is readily soluble in ether and cold concentrated spirit of wine; in alcohol, diluted with an equal volume of water, it dissolves copiously when heated, and partly separates again on cooling; the solution in dilute alcohol is easily decomposed, whereby the yellow colour passes into a deep-red. Chlorokinone exhibits a similar deportment towards acetic acid; it dissolves easily in boiling water, but on ebullition a large quantity is decomposed, a red colour being imparted to the solution; the solution in water, acidulated with hydrochloric acid, may be boiled for some time before the red coloration appears; it dissolves readily in cold aqueous sulphurous acid, and forms, with cold sulphuric acid, a solution which speedily solidifies to a magma of white prisms.—Chlorokinone is capable of assuming 1 or 2 equivs. of hydrogen, and forming compounds which have already been described by Wöhler, viz. *white chlorohydrokinone*,  $C_{12}H_5ClO_4$ , obtained by dissolving kinone in hydrochloric acid; and *brown chlorohydrokinone*,  $C_{12}H_4ClO_4$ , prepared by mixing the former with sesquichloride of iron. By distilling a mixture of chlorokinone, dichlorokinone, and trichlorokinone, with a small quantity of water, a mixture of these three compounds passed over while the contents of the retort acquired a brownish-red colour, and the kinone compounds fused to an almost black mass; the dark-red aqueous solution of the residue, mixed with sulphurous acid gave on evaporation of the now colourless solution a slightly brown crystalline mass, from which chlorohydrokinone in delicate plates could be obtained by sublimation; another portion of the red solution, when agitated with ether, gave an extract which left on evaporation of the ether drops of oil, that soon solidified into delicate crystals of brown chlorohydrokinone. Colourless chlorohydrokinone is obtained by dissolving chlorokinone in sulphuric acid. Brown chlorohydrokinone forms by digesting a warm solution of colourless

Kinone.

chlorohydrokinone with chlorokinone, or by the continued ebullition of chlorokinone with a small quantity of water; it is likewise formed together with green hydrokinone in the first moment of the action of hydrochloric acid upon kinone. If the dark magma formed by treating kinone with hydrochloric acid be washed with a little water, and then with dilute spirit of wine, and the dried residue dissolved in concentrated acetic acid, green hydrokinone will deposit as the solution cools.

*Dichlorokinone*,  $C_{12}H_2Cl_2O_4$ , can be freed from chlorokinone, and from the greater part of the trichlorokinone by maceration with cold alcohol; a portion of the latter which still remains is removed by washing with hot spirits of wine diluted with at least an equal volume of water; the chloranile is separated by re-crystallisation from boiling alcohol, and pouring off the delicate yellow plates of chloranile, which are suspended in the liquid, from the heavier crystals of dichlorokinone. From boiling alcohol dichlorokinone crystallises in pure lemon-yellow crystals, and from a mixture of alcohol and ether in larger and darker vitreous crystals which are prisms with oblique terminal planes; at the ordinary temperature it slowly volatilises and fuses at  $150^\circ$ ; it is insoluble in water, and almost insoluble in cold alcohol; it dissolves, however, to a slight extent in boiling dilute spirit of wine, and abundantly in boiling concentrated alcohol, in cold ether, and in boiling concentrated acetic acid, but in the latter case whatever may remain in solution after cooling, speedily decomposes with a brownish-red coloration. It is soluble without decomposition also in concentrated sulphuric acid, and in hot concentrated nitric acid. Dichlorokinone dissolves with a deep reddish-brown colour in dilute solution of potassa, and after some hours deposits, in delicate prisms, a red potassa-salt, from whose solution, on addition of hydrochloric acid, the acid separates in red prismatic crystals; this acid appears to be analogous to chloranilic acid. Dilute ammonia dissolves dichlorokinone with difficulty; the solution, which is at first yellow, soon becomes red, then blackish-brown, and deposits, on evaporation, crystals of chloride of ammonium, and a substance resembling humin. If dichlorokinone be heated with concentrated aqueous sulphurous acid, a colourless solution is obtained, which, on cooling, yields stellar needles of colourless dichlorhydrokinone  $C_{12}H_4Cl_2O_4$ ; this compound is obtained from a moderately concentrated solution in acetic acid in crystals resembling those of oxalic acid; it sublimes slowly even at  $120^\circ$ , and rapidly between  $150^\circ$  and  $160^\circ$ : at about  $164^\circ$  it fuses to a reddish-brown liquid which, on cooling, becomes again colourless; it dissolves readily in ether, alcohol, warm acetic acid, and boiling water, but only slightly in cold water; it is not decomposed by sulphuric acid, nor by boiling concentrated hydrochloric acid; with solution of potassa it yields a colourless solution, which, on exposure to the air, becomes green, then red, and deposits a violet powder;

with ammonia it forms a yellow solution which speedily becomes red, and gives, with hydrochloric acid, a precipitate of an amorphous and of a crystalline substance. By treatment with nitric acid, or by addition of sesquichloride of iron to a hot aqueous solution it is transformed into dichlorokinone. If sesquichloride of iron be dropped into the solution only so long as the colour still darkens, a compound, analogous to green hydrokinone, separates in small violet prisms or blackish-green needles which are also formed, with reduction of silver, by mixing a solution of colourless dichlorhydrokinone in dilute spirit of wine, with nitrate of silver. This compound, *violet dichlorhydrokinone*, is  $C_{12}H_3Cl_2O_4 + 2HO$ ; at  $70^\circ$ , or when exposed over sulphuric acid, it loses water and becomes yellow. In preparing this compound by nitrate of silver it may likewise be formed in the anhydrous state by suitably concentrating the liquids. Violet dichlorhydrokinone is almost entirely insoluble in cold water; it is dissolved by boiling water or acetic acid, and on cooling again separates, a portion, however, is by this means transformed into the yellow (anhydrous) compound; alcohol, ether, and sulphuric acid convert it into the yellow compound; cold dilute nitric acid has no action upon it, but moderately concentrated acid transforms it into dichlorokinone; aqueous ammonia and potassa dissolve it with a green colour that soon passes into ruby-red; hydrochloric acid produces in the ammoniacal solution a carmine precipitate, but no precipitate in the solution prepared with potassa. *Yellow dichlorhydrokinone*,  $C_{12}H_3Cl_2O_4$ , assumes a red colour at a temperature of  $110^\circ$ , and becomes again yellow on cooling; at  $120^\circ$  it fuses to a red liquid, being decomposed thereby into dichlorokinone and white dichlorhydrokinone; it dissolves with facility in boiling water and separates again on cooling, being partly transformed into the violet compound.

*Trichlorokinone*,  $C_{12}HCl_3O_4$ , is obtained by precipitating the alcoholic solution containing chlorokinone and trichlorokinone (page 217) by water, dissolving the precipitate in moderately strong alcohol at a temperature of about  $60^\circ$ , and allowing the solution slowly to crystallise, when the trichlorokinone first separates in large yellow plates. As soon as the yellow prisms of chlorokinone begin to separate the liquid must be poured off from the yellow plates, which are to be washed with a little spirit of wine and recrystallised from hot alcohol. Trichlorokinone sublimes pretty rapidly at temperatures exceeding  $130^\circ$ , and fuses at  $160^\circ$ . It does not dissolve in cold water, and is only slightly dissolved in either boiling water, cold alcohol, or acetic acid; it dissolves, however, abundantly in boiling alcohol or acetic acid, in ether, and without decomposition in cold concentrated sulphuric acid, and in hot concentrated nitric acid. In dilute potassa-solution the crystals first become green and then dissolve with a reddish-brown colour; after some time a potassa-salt deposits in the form of red needles, the acid of which can be separated in red crystals



Kinone.

by hydrochloric acid. When treated with concentrated ammonia the crystals assume a red colour and then yield a red solution from which small dark-brown crystals are deposited; they appear to be a compound analogous to chloranilammon.—Trichlorokinone, when heated with aqueous sulphurous acid, dissolves to a colourless liquid from which, after concentration in a water-bath, *colourless trichlorohydrokinone* is separated in colourless plates or in heavy oily drops which become crystalline on cooling. Städeler assumes the formula  $C_{12}H_5Cl_3O_4$  for trichlorohydrokinone, which he did not analyse, from want of the pure substance. It fuses at a temperature a little above  $130^\circ$ , and sublimes in delicate plates. In cold water it is slightly soluble, in boiling water it fuses and dissolves slowly; it dissolves with facility in alcohol and in ether, forming acid solutions that yield a white precipitate with neutral acetate of lead. Concentrated sulphuric acid dissolves it at a moderate temperature, and concentrated nitric acid transforms it into yellow trichlorokinone. The solution in potassa which is at first colourless becomes, when exposed to the air, green, then red, finally brown, and gives with hydrochloric acid a brown precipitate which appears to be a mixture: it dissolves in ammonia with similar changes of colour, the solution yielding with hydrochloric acid a flesh-coloured precipitate. A solution of colourless trichlorohydrokinone in dilute spirit of wine produces with nitrate of silver, when heated, a silver-mirror, and on cooling deposits small yellow plates which are likewise formed on adding sesquichloride of iron to an aqueous solution of trichlorohydrokinone. According to Städeler this compound is identical with that obtained by Woskresensky(1) on acting upon kinone by chlorine and subliming the product in an atmosphere of chlorine, and to which he assigned the name chlorokinoyl; Städeler states, moreover, that its composition must be expressed by the formula  $C_{12}H_2Cl_3O_4$ , with which also Woskresensky's analyses agree very closely.

If *chloranile*,  $C_{12}Cl_4O_4$ , is boiled with aqueous sulphurous acid, the crystals become brownish-white; the product is obtained in white plates of perfect purity by washing with cold water, recrystallising from a mixture of ether and dilute spirit of wine and then from boiling concentrated acetic acid. This compound is chlorohydroanile  $C_{12}H_2Cl_4O_4$ ; it becomes slightly brown at  $160^\circ$ , dark-brown between  $215^\circ$  and  $220^\circ$ , and commences at this temperature to sublime rapidly; at a stronger heat it fuses. It dissolves with facility in dilute potassa-solution, and produces therewith a potassa-salt in slightly coloured crystals; the solution and also the crystals rapidly become red when exposed to the air. Ammonia dissolves it with a yellow colour, an excess of hydrochloric acid changing the colour of the solution to violet, without, however, producing a precipitate.

(1) J. Pr. Chem. XVIII, 419; Berzelius' Jahresber. XX, 448.

With water containing some sesquichloride of iron or nitric acid, it becomes, when heated, immediately yellow; the yellow compound is also formed on adding nitrate of silver to a solution of chlorohydroanile in dilute spirit of wine. In contact with hypochlorite of soda, chlorohydroanile, and also the solutions of colourless di- and trichlorohydrokinone became green.

Kinone.

**Gallic Acid.**—Wittstein(1), by his investigations of the compounds of iron with gallic acid, has arrived at the following conclusions, viz., that a constant compound is not to be obtained, but that the precipitate, prepared with pure salts of the protoxide or of the sesquioxide, contains the two oxides, and in fact at least as many equivalents of protoxide as of the sesquioxide. He states that the quantity of protoxide increases the longer the precipitate remains in the liquid in which it is produced, while the sesquioxide augments in quantity by drying the precipitate at  $100^{\circ}$ .

**Tannocaffeic Acid.**—Liebich(2) has investigated the action of potassa upon tannocaffeic acid. The acid, moderately concentrated by evaporation, was mixed with pure potassa, until the solution acquired a distinctly alkaline reaction; it immediately assumed a brown colour, and gradually became darker by exposure to the air. After eight days a portion of the liquid was neutralised with acetic acid, and precipitated by neutral acetate of lead; the light-brown precipitate yielded from 28.4 to 28.7 per cent of carbon, 1.9 to 2.2 hydrogen, and 51.0 to 51.3 protoxide of lead, from which Liebich has deduced the formula  $4(\text{PbO}, \text{C}_{12}\text{H}_5\text{O}_6) + 3\text{PbO}, 2\text{C}_{12}\text{H}_6\text{O}_5$ . The remaining portion of the liquid was exposed to the air for eight days longer, and a blackish-brown lead-salt prepared therefrom, which gave 21.2 to 21.5 per cent of carbon, 1.5 to 1.6 hydrogen, and 60.2 to 60.5 protoxide of lead; for which, as for a mixture of a basic with a neutral salt, Liebich has calculated the formula  $5(2\text{PbO}, \text{C}_{12}\text{H}_4\text{O}_7) + \text{PbO}, \text{C}_{12}\text{H}_4\text{O}_7$ . Liebich states that, by the above-mentioned treatment, tannocaffeic acid splits in such a manner that a group of atoms,  $\text{C}_{12}\text{H}_6\text{O}_5$ , becomes free, passing into  $\text{C}_{12}\text{H}_5\text{O}_6$ , and finally into  $\text{C}_{12}\text{H}_4\text{O}_7$ .

**Non-volatile Acids of Valerian-Root.**—Runge had stated, that in the root of *Valeriana officinalis*, &c., an acid is contained that forms with bases white salts which become green by exposure to the air; he named it greenous acid, and its product of oxidation greenic acid. Czyrniarsky(3) has made the following observations. Fresh valerian roots were exhausted with hot absolute alcohol, and the extract precipitated by neutral acetate of lead; the dirty-white precipitate, washed with boiling alcohol, was suspended in water, and

(1) Repert. Pharm. [3] II, 200.

(2) Ann. Ch. Pharm. LXXI, 57.

(3) Ann. Ch. Pharm. LXXI, 21.

Non-volatile acids  
of valerian-  
root.

decomposed by hydrosulphuric acid; the liquid gave, with acetate of lead, a whitish-yellow precipitate which, when dried *in vacuo*, contained 17.5 per cent carbon, 1.9 hydrogen, 13.4 oxygen, and 67.2 protoxide of lead, and soon acquired a green colour on exposure to the air. The composition of its acid Czynniansky considers as  $C_{14}H_9O_8$ , which is tannocaffeic acid + 1 equiv. of water. The free acid decomposes by exposure to the air, reduces silver-salts, gives with baryta a white compound, and in contradistinction to tannocaffeic acid does not become green on addition of salts of sesquioxide of iron, nor brown when exposed with ammonia to the atmosphere. The liquid, filtered from the first precipitate, gave, when mixed with a small quantity of ammonia, a copious precipitate which was decomposed by hydrosulphuric acid; the filtrate yielded, with tribasic acetate of lead, a precipitate in which 15.2 per cent of carbon, 1.6 hydrogen, 14.3 oxygen, and 68.9 protoxide of lead were found, corresponding, according to Czynniansky, to the formula of the acid  $C_{12}H_8O_9$ ; the acid of this salt likewise reduces the silver-salts, and does not yield an insoluble salt of baryta.

**Benzoic Acid.**—Chancel(1) has subjected the products of decomposition formed in the dry distillation of benzoate of lime to a new investigation which has as yet been published only in abstract. According to the author, the products of decomposition of benzoate of lime are by no means carbonate of lime and benzone only, but inflammable gases are always simultaneously evolved; the distillate which has hitherto been termed benzone, and supposed to be represented by the formula  $C_{13}H_5O$ , is, according to Chancel, a mixture of several bodies, from which a crystalline substance may be isolated. This latter compound has the composition ascribed to benzone, viz.,  $C_{13}H_5O$ , or as Chancel, according to his views regarding the constitution of the acetones(2), writes,  $C_{26}H_{10}O_2$ ; it is insoluble in water, pretty soluble in alcohol, and very soluble in ether; it crystallises in large, slightly amber-coloured prisms, fuses at  $46^\circ$  to a thick oil, commences to boil at  $315^\circ$ , and distils over unchanged. With a mixture of potassa and lime, it forms at about  $200^\circ$  only benzoate of potassa and benzole (phène), without a trace of hydrogen ( $C_{26}H_{10}O_2 + KO, HO = KO, C_{14}H_5O_3 + C_{12}H_6$ ); in reference to this latter decomposition, Chancel proposes to term it *benzophenone*. In the cold, benzophenone is dissolved by sulphuric or nitric acid without decomposition, and is again separated on addition of water, heated fuming nitric acid acts thereon, and transforms it into an oily liquid which retains its fluidity a considerable time

(1) Compt. Rend. XXVIII, 83; Laur. and Gerh. C. R. 1849, 87; Instit. 1849, 19 Ann. Ch. Pharm. LXXII, 279.

(2) Comp. Annual Report for 1847-8, I, 418.

after being cooled; this body which is *dinitro-benzophenone*,  $C_{26}H_8(NO_4)_2O_2$ , dissolves rapidly in ether, but almost immediately separates again as a crystalline, slightly yellow powder.—In addition to benzophenone, the products of the distillation of benzoate of lime contain benzole and other substances, especially carbohydrides. Chancel was unable to detect naphthalin ( $C_{20}H_8$ ); but he found two other carbohydrides isomeric therewith; one of these compounds crystallises readily, and fuses at  $92^\circ$ , whilst the other is less soluble in ether and alcohol, crystallises imperfectly, and fuses at  $65^\circ$ ; the latter possesses the odour of roses, and is identical with the compound obtained by Chancel and Laurent in the decomposition of benzoate of ammonia by red-hot caustic baryta(1); it is likewise formed in more considerable quantity in the distillation of a mixture of benzoate of potassa and potassa-lime.

Chancel(2) has, moreover, published investigations upon the nitro-compounds derived from benzoic acid, and of their products of decomposition.—He prepared *nitrobenzoate of ethyl*, ( $C_4H_5O$ ,  $C_{14}H_4(NO_4)O_3$ ), by passing hydrochloric acid gas into a boiling alcoholic solution of nitrobenzoic acid; the compound in a short time separates at the bottom of the vessel, and solidifies on cooling; it crystallises in rhombic prisms of  $122^\circ$ , fuses at  $42^\circ$ , and boils at about  $298^\circ$ .—*Nitrobenzoate of methyl*, prepared in a similar manner, crystallises in rhombic prisms of  $118^\circ$  to  $120^\circ$ , fuses at  $70^\circ$ , and boils at  $279^\circ$ . For the preparation of *nitrobenzamide*,  $C_{14}H_6(NO_4)NO_2$ , which Field(3) obtained by heating nitrobenzoate of ammonia, Chancel prefers mixing nitrobenzoate of ethyl, dissolved in a large amount of alcohol, with aqueous ammonia, in quantity insufficient to separate the ether, allowing the mixture to remain in a closed vessel, and evaporating as soon as a portion ceases to become cloudy on addition of a large quantity of water, which, at the ordinary temperature, is generally the case in about eight or ten days.—In reference to the action of sulphide of ammonium upon nitrobenzamide, comp. carbanilamide and carbanilic acid.

(1) Laurent and Chancel (Laur. and Gerh. C. R. 1849, 117; J. Pr. Chem. XLVI, 510) state that, by passing benzoate of ammonia over heated baryta, the latter becomes red-hot, and benzonitrile, together with a small quantity of a crystalline compound, collects in the receiver. The latter, when purified by distillation and recrystallisation from alcohol, formed colourless plates, which smelt feebly of roses, volatilised without decomposition, and had the same composition as naphthalin; it gives with bromine a crystalline substance.—At a former period (comp. Annual Report for 1847-8, I, 458) Laurent and Chancel had stated that only benzole was obtained on passing benzoate of ammonia over red-hot baryta.

(2) Laur. and Gerh. C. R. 1849, 177; J. Pr. Chem. XLVII, 140; Ann. Ch. Pharm. LXXII, 274 (in abstr.).

(3) Annual Report for 1847-8, I, 454.

Benzoic  
acid.

According to a short note, Chancel(1) has subsequently found that by the action of sulphide of ammonium upon nitrobenzoate of ethyl, carbanilate of ethyl  $C_{18}H_{11}NO_4$ , which he terms *carbanilethane* is formed; and by acting in a similar manner upon nitrobenzoate of methyl, he obtains carbanilate of methyl  $C_{16}H_9NO_4$  (*carbani-methylane*.) Both compounds are fluid, insoluble in water, and do not volatilise without decomposition; by the continued action of ammonia they are decomposed with formation of carbanilamide and alcohol.

**Fosresinic Acid.**—Bastick(2) has studied the action of nitric acid upon a fossil resinous body which is found at Highgate near London(3.) This substance is insoluble in water, with difficulty soluble in spirit of wine, and readily soluble in ether; it possesses the sp. gr. of 1.05, and the hardness of colophony. Solution of potassa acts only slightly upon it, but sulphuric acid dissolves it with development of a purple-brown colour. Nitric acid oxidises it especially when heated; it yields no oxalic acid, but a new acid is formed, which he terms *fosresinic acid*. This body is thrown down on addition of water as a yellow non-crystalline precipitate, which is slightly soluble in cold, and more readily in hot water; it is soluble in ether and spirit of wine, and possesses a strongly acid and bitter taste; it forms soluble, reddish-brown uncrystallisable salts with the alkalies, and insoluble salts with the earths and oxides of the heavy metals.

**Anilic Acid.**—Stenhouse(4) has found that anilic acid is decidedly attacked by chlorine. By digesting the acid with a mixture of chlorate of potassa and hydrochloric acid, it is quickly transformed into chloranile without the simultaneous formation of chloropicrin. Anilic acid suffers the same change when chlorine is continually passed into its hot saturated solution. By the ebullition of anilic acid with hypochlorite of lime, no chloropicrin is formed, but the solution assumes a dark-brown colour, and hydrochloric acid separates therefrom a number of flocks which unite into a resin. The action of chlorine offers a simple means of distinguishing anilic acid from picric, oxypicric (styphnic acid) and chrysamic acid.

**Action of Nitric Acid upon Organic Acids.**—Reinsch(5) has published some statements regarding several acids produced from organic acids by the action of fuming nitric acid, and termed by him new double acids. He states that a solution of 1 part of tartaric acid in 5 parts of fuming nitric acid of 1.42 sp. gr. soon solidifies to a mass of delicate crystalline needles, which is probably a compound of an-

(1) Instit. 1849, 252.

(2) Pharm. J. Trans. VIII, 339; J. Chim. Méd. [3] V, 383.

(3) Respecting the earlier investigations of this earthy resin, comp. Rammelsberg's Handwörterb. der Mineral. II, 95.

(4) Ann. Ch. Pharm. LXX, 253.

(5) Jahrb. Pr. Pharm. XVIII, 189; Repert. Pharm. [3] III, 20.

Action of  
nitric acid  
upon organic  
acids.

hydrous tartaric acid and anhydrous(?) nitric acid, since it decomposes into these two acids on addition of water.—A solution of effloresced oxalic acid in moderately warmed fuming nitric acid yields on cooling vitreous crystals which are readily decomposed, and probably contain equal equivalents of oxalic and nitric acids(?). Benzoic acid forms with nitric acid likewise a new acid; Reinsch, however, appears to pay no regard to the existence of nitrobenzoic acids; he thinks it moreover probable that also citric and succinic acid, and even boracic acid, exhibit the same deportment.

**Products of the Decomposition of Aloes by Nitric Acid.**—Schunck and Mulder(1) had formerly published investigations upon the products of the decomposition of aloes by nitric acid, and of chrysamic; their observations, however, did not accord. Mulder(2) has now published the results of more recent investigations.

1 part of aloes is heated with 8 of nitric acid until the action ceases, and the liquid evaporated until a yellow powder separates; water is added to the cooled liquid, and the powder which deposits is washed with water and treated with alcohol. The chrysamic acid, which is much less soluble in cold alcohol, remains after cooling almost entirely undissolved; the liquid which is filtered off deposits, on farther evaporation, first, aloetic acid, which may still contain a portion of chrysamic acid, then pure aloetic acid, whilst in the remainder of the liquid Schunck's aloeresinic acid remains dissolved.—*Aloetic acid* is obtained free from chrysamic acid, aloeresinic acid, &c., by repeatedly dissolving the product, deposited as a yellow powder, in boiling alcohol, and allowing the solution to cool; it is a crystalline orange-yellow powder which is little soluble in cold, and more soluble in boiling water; in both liquids it is more soluble than chrysamic acid, moreover it is never of so pure a yellow, or greenish-yellow, as the latter, but is more of an orange colour. The composition of the acid, dried at  $120^{\circ}$ , is  $C_{14}H_2N_2O_{10} + HO$ , whilst Schunck had assumed for this acid the formula  $C_{16}H_4N_2O_{13}$ . It forms readily-soluble salts with potassa and soda. By digestion with an excess of solution of acetate of baryta, it forms an almost insoluble baryta-salt  $BaO, C_{14}H_2N_2O_{10}$ , which on precipitation by acetate of lead gives a dark-red, insoluble precipitate,  $2 PbO, C_{14}H_2N_2O_{10}$ .—Aloetic acid dissolves in ammonia with a violet colour. If placed in an atmosphere of pure ammoniacal gas at the ordinary temperature, or some degrees below  $0^{\circ}$ , an explosion takes place, and a black carbonaceous mass remains; if, however, the ammoniacal gas is diluted with a large quantity of atmospheric air, no explosion occurs, but water is eliminated and the

(1) Comp. Annual Report for 1847-8, I, 415.

(2) Scheik. Onderzoek. V, 173; J. Pr. Chem. XLVIII, 9; Ann. Ch. Pharm. LXXII, 285; Chem. Gaz. 1849, 358, 297. Respecting Laurent's view on the allied compounds, comp. Laur. and Gerh. C. R. 1850, 163.

Products  
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composi-  
tion of  
aloës by  
nitric acid.

substance assumes a dark-red colour; the product thus obtained is *aloetamide* which has the composition  $C_{14}H_6N_3O_{10}$ , when dried at  $100^\circ$ .—*Hydroaloetic acid*, represented in the hypothetical anhydrous state by the formula  $C_{14}H_4N_2O_{11}$ , is formed by the action of water and protochloride of tin upon aloetic or chrysamic acid; it forms a dark-violet, heavy powder which, when dried at  $120^\circ$ , has the composition  $SnO_2, C_{14}H_4N_2O_{11}$ . Mulder considers hydroaloetic acid as an amidogen-compound. The tin-compound, when treated with solution of potassa, evolves ammonia and assumes a violet-blue colour; when heated with concentrated nitric acid, it is first converted into aloetic acid, and by continued ebullition into chrysamic acid, vapours of nitrous acid being simultaneously evolved from the reddened solution.—According to Mulder, Schunck's chrysaminamide is probably a compound of the chrysamide discovered by Mulder with ammonia, his amidochrysamic acid, a mixture of chrysamide and green chrysamic acid, and finally, his amidochryamate of baryta nothing more than chryamate of baryta. There exist, moreover, definite compounds of chrysamide and chrysamic acid, of which the simplest is  $C_{14}H_4N_3O_{11} + C_{14}H_2N_2O_{12}$ ; if chrysamic acid is treated with ammonia, and the liquid, after its perfect conversion into chrysamide, is mixed with chloride of barium, a precipitate is formed which, when dried in the air, has evidently the formula  $BaO, C_{14}H_4N_3O_{11} + xH_2O$ , but when dried at  $120^\circ$  it is represented by  $BaO, C_{14}HN_2O_{11} + BaO, C_{14}H_3N_3O_{10}$ .—The compound termed by Mulder *Aloeresinic acid*, is the acid contained in the brown residue of the liquid which remains after the separation of chrysamic and aloetic acids (see p. 225). The same name had originally been assigned to this acid by Schunck, who had, however, found for it a composition differing from that arrived at by Mulder; subsequently, he regarded it as identical with a product of the decomposition of chrysamic acid; but Mulder considers it to be different, and has distinguished it as chrysatric acid. The brown residuary liquid, which contains moreover a portion of oxalic and nitric acids, is saturated with carbonate of lime, and the filtrate precipitated by acetate of lead; the lead-salt thus produced contains protoxide of lead, varying in quantity from 58 to 62 per cent, but the aloeresinic acid, which is present therein has invariably the same composition,  $C_{14}H_8NO_{12}$ . Aloeresinic acid produces with lime, soda, potassa, and baryta, brown soluble non-crystallisable salts, and with the oxides of lead, copper and silver, brown insoluble salts which, on ebullition with concentrated nitric acid yield in the first instance aloetic acid, and finally chrysamic acid.—*Chrysatric acid* which, in the lead-salt, dried at  $130^\circ$ , has the formula  $C_{24}H_6N_3O_{15}$ , is formed from either chrysamic or aloetic acid by heating with solutions of the fixed alkalies; the brown liquid thus obtained is diluted with water, heated with an excess of acetic acid, and after cooling precipitated by acetate of lead, when a

Products  
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nitric acid

brown compound is separated in which the organic constituent has the above-mentioned composition, and in which the proportion of protoxide of lead amounts to 58·7 per cent. Chrysatric acid is not again transformed into chrysamic acid by treatment with nitric acid.—By the action of boiling hydrated sulphuric acid upon chrysamic acid a violet-coloured substance is rapidly formed, attended by a copious evolution of nitrous vapours; this body is termed by Mulder *Chryiodin*,  $C_{56}H_8N_3O_{28}$ , or more probably a conjugate compound of  $C_{28}H_4NO_{15}$  with  $C_{28}H_4N_2O_{13}$ . When heated with strong nitric acid it yields nitrous vapours and a red liquid which when treated with potassa gives no chrysamate of this base; it dissolves with difficulty in dilute solution of potassa, forming a violet liquid, and is precipitated therefrom by hydrochloric acid as a violet-coloured jelly. Chryiodin, when treated with solution of ammonia, is transformed into two indigo-blue bodies, one being insoluble therein, and the other soluble; the former, which is *chryiodamide*, is represented, when dried at  $120^\circ$ , by the formula  $C_{28}H_8N_3O_{13}$ , and the latter, *oxide of chryiodan ammonium*, when dried at the same temperature, by  $C_{28}H_{10}N_4O_{13}$ .—When chrysamide is heated with ammonia and hydrosulphuric acid passed into the solution, it assumes in the first instance a violet, and finally a blue colour; the evaporated filtrate yields a residue which is with difficulty obtained free from sulphur, and consists of *oxide of chrysindin ammonium*, having the composition  $C_{28}H_8N_5O_{13}$  (at  $130^\circ$ ). If potassa be added to the solution of this body, a precipitate is obtained of the formula  $C_{25}H_5N_4O_{13}$ . If hydrosulphuric acid be passed through a solution of chrysamic acid in ammonia, and the solution be boiled and filtered, it yields on evaporation a blue deposit which is identical with the first product of the action of hydrosulphuric acid on chrysamide; this compound, which Mulder terms *chrysindamide*, has, when dried at  $120^\circ$ , the composition  $C_{28}H_9N_5O_{18}$  it could not, however, be obtained perfectly free from sulphur.—If an excess of sulphurous acid be passed through a solution of chrysamic acid in ammonia, or if a solution of sulphurous acid be heated with chrysamic acid, ammonia being subsequently added, a brown liquid is obtained, which is not precipitated by hydrochloric acid. If, however, an excess of sulphurous acid be avoided, a violet solution is formed, from which hydrochloric acid precipitates a brown jelly, with simultaneous evolution of sulphurous acid.

**Separation of some of the Acids  $C_nH_nO_4$ .**—Liebig(1) has published some farther details regarding the method, given in the last Annual Report, Vol. I, 427, for separating some of the acids  $C_nH_nO_4$ . In order to detect the presence of, and to separate small quantities of either butyric or valeric acid, in a mixture of these acids, a portion of the acid mixture is saturated with potassa or soda, then added to the



Separation  
of some of  
the acids  
 $C_nH_{2n}O_2$ .

remaining quantity of the mixture, and the whole submitted to distillation. If a quantity of valeric acid is present in the mixture sufficient to neutralise the whole of the alkali, the residue will contain pure valeric acid; if, however, the quantity of valeric acid is less, butyric acid will likewise remain in the residue, but the distillate in this case contains pure butyric acid. The quantity of the acid mixture to be neutralised with alkali is determined by the quantity of valeric acid supposed to be present; if we have reason to assume that  $\frac{1}{10}$ th of the acid mixture consists of valeric acid,  $\frac{1}{10}$ th of the mixture must be neutralised. By this procedure, one of the two acids is invariably obtained in a state of purity. A mixture of valeric and acetic acids, or of butyric and acetic acids, exhibits a perfectly different comportment; by partially neutralising with potassa and distilling, the more volatile acetic acid does not by preference pass over, but, on the contrary, valeric or butyric acid. The cause of this phenomenon is the formation of an acid salt, which does not appear to be decomposed by either of the other two acids. Valeric acid dissolves immediately, and to a considerable extent, in a solution of neutral acetate of potassa, whilst by a solution of the acid acetate, it is not taken up in larger quantity than by water. If a solution of neutral acetate of potassa is mixed with an excess of valeric acid, and subjected to distillation, the latter acid passes over, whilst acid acetate and valerate of potassa remain in the residue; but if the acid acetate of potassa is distilled with valeric acid, the latter entirely distils over, and acid acetate of potassa alone remains in the residue. Butyric acid exhibits a deportment analogous to that of valeric acid. If butyric or valeric acid, containing acetic acid, is partially saturated by potassa, and distilled, either all the acetic acid remains as an acid salt, together with butyric or valeric acid as residue, the distilled acid in this case being free from acetic acid, or there remains in the residue only acetic acid, and none of the other acids. The distillate may then be farther separated by a similar treatment.

**Formic Acid.**—Gorup-Besanez(1) has found that formic acid is present in the sap of the common nettle.

**Acetic Acid.**—Laux(2) and Bley & Diesel(3) have published some observations upon the preparation of *Acetum concentratum*; and H. Becker(4) upon *Tinctura ferri acetici aetherea* and the official solution of acetate of iron.

Kolbe(5) has investigated the decomposition of acetic acid by the electric current. In the electrolysis of a saturated solution of acetate

(1) Repert. Pharm. [2] IV, 29; J. Pr. Chem. XLVIII, 191; Ann. Ch. Pharm. LXXII, 267.

(2) Arch. Pharm. [2] LVII, 14.

(3) Arch. Pharm. [2] LVIII, 16.

(4) Arch. Pharm. [2] LIX, 261.

(5) Ann. Ch. Pharm. LXIX, 279; Chem. Soc. Qu. J. II, 173.

of potassa, only gaseous products are eliminated, viz., carbonic acid, hydrogen, an inodorous combustible gas, together with a gas of an ethereal odour, which is perfectly absorbed by sulphuric acid. He states that by the presence of the minutest quantity of chloride of potassium in the solution, chloride of methyl is formed. The gaseous mixture which is evolved, when freed from carbonic acid, gave in one experiment 0.7 oxygen, 63.8 hydrogen, 32.6 methyl ( $C_2H_3$ ), 2.1 oxide of methyl, 0.8 acetate of methyl, in 100 volumes; in another experiment, 66 volumes of hydrogen to 28 volumes of methyl. When the solution of acetate of potassa is separated by a porous diaphragm, in such a manner as to admit of the gaseous products of decomposition eliminated at the two poles being separately collected, only hydrogen is evolved at the negative pole, whilst at the positive pole a gaseous mixture is disengaged, which, after treatment with potassa and sulphuric acid, leaves as a residue only methyl-gas, mixed with a small quantity of oxide of methyl. The gaseous methyl obtained in this manner is identical with that prepared by the action of potassium upon cyanide of ethyl.(1) According to Kolbe, if we leave out of consideration the small quantity of oxide of methyl which is formed, the decomposition of acetic acid is explained by the equation  $C_4H_4O_4 = C_2H_3 + 2CO_2 + H$ . Accordingly, the gaseous mixture which is evolved ought to contain equal volumes of hydrogen and methyl, whilst, in fact, a volume of hydrogen nearly double that of the methyl was observed, no corresponding volume of oxygen being simultaneously disengaged. Kolbe states that the process is certainly attended by a decomposition of water, but that the oxygen thus released oxidises a portion of the simultaneously evolved methyl to water and carbonic acid.

**Propionic Acid.**—Regarding Nicklès' statements upon propionate of copper, comp. p. 13.

**Butyric Acid.**—According to H. Schulze(2), when wheaten flour is mixed with water and  $\frac{1}{3}$ rd of its weight of carbonate of lime, and maintained at a temperature of from  $25^\circ$  to  $37^\circ$ , butyric acid is formed as a product of the fermentation; but when cheese is added to the mixture, its formation is accomplished with greater rapidity, and with simultaneous production of lactic acid.

Salvétat(3) has published some observations, according to which butyric acid is formed in the spontaneous decomposition of safflower under circumstances, however, which have not yet been accurately established.

(1) Annual Report for 1847-8, II, 16. Regarding methyl, comp. at iodide of ethyl, in this Report.

(2) Arch. Pharm. [2] LVII, 272.

(3) Ann. Ch. Phys. [3] XXV, 337; J. Pharm. [3] XV, 269; J. Pr. Chem. XLVI., 475; Ann. Ch. Pharm. LXXII, 267 (in abstr.).

Valeric  
acid.

**Valeric Acid.**—Kolbe(1) has now published, more in detail, his investigations upon the decomposition of valeric acid by the electric current, a notice of which, has already appeared in the Annual Report for 1847-8, I, 429. By the electrolysis of a saturated solution of pure valerate of potassa, surrounded by water at a temperature of  $0^{\circ}$ , the products of decomposition were found to be hydrogen, carbonic acid, a gaseous carbohydrogen, and a light oily product. When the two poles of a Bunsen's zinco-carbon battery of 4 elements were separated from each other by a porous diaphragm, only the hydrogen was eliminated at the negative pole, whilst the other products of decomposition appeared at the positive pole which terminated in a platinum plate. In a solution of valerate of potassa, which is but moderately heated, a perfectly different decomposition takes place.—The boiling-point of the light oily liquid, dried over chloride of calcium, rose from  $100^{\circ}$  to  $160^{\circ}$ . On boiling this substance with an alcoholic solution of potassa, and allowing the condensed vapours to return to the flask, aqueous valerate of potassa is found to separate as a heavy oil, which is farther decomposed by continued ebullition. If the cooled liquid be mixed with a large excess of water, a light ethereal oil is separated, which after being washed with water, dried over chloride of calcium, and rectified, boils constantly at  $108^{\circ}$ ; this substance possesses an agreeable ethereal odour, mixes in all proportions with alcohol and ether, is very inflammable, and burns with a very smoky flame; at  $18^{\circ}$  its sp. gr. is 0.694. The composition of this body, which may be called *Butyl*(2), is  $C_8H_9$ ; the density of its vapour is 4.05 corresponding to the formula  $C_8H_9$ , the calculated density being 3.94, if we assume a condensation to 2 volumes. Ordinary nitric acid, or a mixture of bichromate of potassa and sulphuric acid, has no action upon butyl even on continued ebullition. Strong fuming nitric acid, especially on addition of sulphuric acid, oxidises butyl completely on protracted ebullition; the liquid thus obtained is saturated with carbonate of baryta, evaporated, and the baryta-salt of the newly-formed acid extracted by boiling alcohol; if now the extract is evaporated, and the residue, dissolved in a little water, is distilled with sulphuric acid, a yellow liquid passes over smelling strongly of butyric acid. Kolbe considers this liquid to be a mixture of butyric and nitrobutyric acids  $[C_8H_7(NO_4)O_4]$ , its composition, however, could not be determined from want of material. Dry chlorine appears to have no influence in the dark upon butyl, but the smallest ray of light

(1) Ann. Ch. Pharm. LXIX, 257; Chem. Soc. Qu. J. II, 157; J. Pharm. [3] XVI, 385.

(2) Kolbe originally proposed the term *Valyl*, for which we have substituted the name *Butyl*, to indicate the position of this body.—Eds.

suffices to induce the formation of hydrochloric acid vapours, and chlorinated substitution-products; the liquid, by an excess of chlorine, being finally transformed into a difficultly mobile, almost viscid mass. Butyl unites with bromine under similar phenomena, the action however is more feeble; it dissolves iodine in quantity, but it forms therewith no combination; nor does it unite with sulphur.—In the Annual Report for 1847-8, it was stated that Kolbe considers the body mixed in the crude oil with butyl to be valerate of oxide of butyl  $C_8H_9O$ ,  $C_{10}H_9O_3$ ; the analysis of the crude oil, in fact, corresponds with a mixture of such a compound with butyl.—The gaseous carbohydrogen, formed in the electrolysis of valerate of potassa, when freed from carbonic acid by potassa, and from the odorous body by fuming sulphuric acid, has the same composition as olefiant gas; it has, however, double the sp. gr. of the latter body, and appears to be identical with the compound  $C_8H_8$ , which was discovered by Faraday, and named by Berzelius *Ditetryl*. A mixture of this carbohydrogen and hydrogen, when brought into contact with dry chlorine, forms vapours of hydrochloric acid and an oily liquid; in conducting the experiment, an excess of chlorine is to be carefully avoided, and the glass globe, which is liable to become slightly warmed by the reaction, is to be excluded as much as possible from daylight. The oily body thus obtained is first washed with slightly alkaline, and then with pure water, dried by chloride of calcium, and distilled. The liquid distilling at a temperature between  $125^\circ$  and  $130^\circ$ , forming the chief bulk of the distillate, is separately collected, and repeatedly rectified till a fluid is obtained, boiling pretty constantly at  $123^\circ$ . This liquid is colourless, ethereal, and of sweetish odour and taste, strikingly similar to those of chloride of elayl; it is insoluble in water, but dissolves with facility in ether and in alcohol; its sp. gr. at  $18^\circ$  is 1.112, and its composition  $C_8H_8Cl_2$ . Assuming a condensation to 4 volumes the vapour-density of this substance is 4.38, the experimental number being 4.43. On heating an alcoholic solution of this compound with an alcoholic solution of potassa, an abundant precipitate of chloride of potassium is produced, together with a volatile oily compound of a somewhat different odour, probably of the composition  $C_8H_7Cl$ , and which may be separated from the alcoholic liquid by addition of water.—Kolbe, moreover, alludes to the fact that, if we assume for this compound, which boils at  $123^\circ$ , the formula  $C_8H_8Cl_2$ , and for chloride of elayl, or oil of olefiant gas, boiling at  $85^\circ$ , the expression  $C_4H_4Cl_2$ , the difference of composition  $2C_2H_2$  accurately corresponds to the difference in the boiling-points, which is  $38^\circ = 2 \times 19^\circ$ .—According to Kolbe the oxidising influence of the oxygen liberated in the circuit of the galvanic current induces three distinct phenomena in a solution of valerate of potassa: 1. Decomposition of the acid itself into butyl and carbonic acid; 2. Decompo-

Valeric  
acid.

sition of butyl into diteteryl and water; 3. Oxidation of butyl into oxide of butyl, which at the moment of its formation combines with the free valeric acid.

1.  $C_{10}H_{10}O_4 + O = C_8H_9 + 2CO_2 + HO.$
2.  $C_8H_9 + O = C_6H_8 + HO.$
3.  $C_8H_9 + O + C_{10}H_{10}O_4 = C_8H_9O, C_{10}H_9O_3 + HO.$

The two latter processes appear to proceed simultaneously, and independently of each other. Kolbe could not ascertain with certainty what circumstances particularly favour the one or the other process.

**Caprylic Acid. Caprylone.**—Guckelberger (1) has investigated caprylone which is formed by the dry distillation of caprylate of baryta, the caprylic acid ( $C_{16}H_{16}O_4$ ) employed for the preparation being obtained from cocoa-nut oil. In the preparation of this substance, separation of carbon, and other secondary decompositions, are avoided, by distilling the baryta-salt, mixed with double its weight of hydrate of lime, and taking the precaution to heat the mixture as rapidly as possible throughout its entire mass to the requisite temperature, which is that of low redness. The vapours which pass over condense in the receiver to a yellow oily liquid which in a short time solidifies to a yellow mass resembling butter. This substance, which is caprylone, is pressed between folds of bibulous paper, and recrystallised from boiling alcohol. Caprylone which has, when thus purified, the composition  $C_{15}H_{15}O$ , or  $C_{30}H_{30}O_2$ , is perfectly white, and floats upon water, but sinks in alcohol of 0.89 sp. gr.; at  $40^\circ$  it fuses, and at  $38^\circ$  it solidifies to a radiated crystalline mass; at  $178^\circ$  it enters into ebullition, and distils over without suffering decomposition. It is insoluble in water, but dissolves with facility in ether, fatty and ethereal oils; in alcohol of 80 per cent, it dissolves freely, even in the cold, and in boiling alcohol, or pyroxylic spirit, in so large a proportion that the solution on cooling solidifies into a mass. It is not affected by potassa, and even fuming nitric acid has no action upon it in the cold. On the other hand, nitric acid of 1.4 sp. gr. acts violently upon fused caprylone, and the vapours which are evolved therefrom impart an ethereal odour to water through which they are passed. The caprylone is converted into a yellow oily liquid, heavier than water, in which it is scarcely soluble; it dissolves, however, in aqueous solutions of the alkalies, and yields, with ammoniacal solutions of silver- and lead-salts, precipitates of a yellow colour; its silver-compound readily decomposes and detonates when gently heated. This substance is analogous to that which Chancel obtained by the action of nitric acid upon butyrone, and the cor-

(1) Ann. Ch. Pharm. LXIX, 201; Chem. Gaz. 1849, 139.

responding name of nitrocaprylonic acid (nitrocœnanthylic acid?) might be given to it.

Stearic acid.

**Stearic Acid.**—Chevreul(1), some time ago, had doubted whether stearic and margaric acids had not actually the same composition. Laurent and Gerhardt(2) have now given an affirmative answer to this question. They remind us of the similarity of the chemical department of this acid to that of margaric acid, and that the quantities of base in the salts of the two acids were found to be nearly equal. Moreover they do not believe it possible that stearic acid could contain an uneven number of equivalents of oxygen with an even number of equivalents of carbon and hydrogen. They analysed stearic acid of different preparations, and found it to contain from 75.40 to 75.60 per cent of carbon, 12.53 to 12.61 hydrogen, and 11.79 to 12.06 oxygen. They assign to stearic acid the same formula as to margaric acid, viz.,  $C_{34}H_{34}O_4$ , which requires 75.55 per cent of carbon, 12.56 hydrogen, and 11.89 oxygen; in stearate of silver they found a quantity of silver, corresponding with the formula  $AgO, C_{34}H_{33}O_3$ ; the amount of silver found was from 28.52 to 28.75 per cent, the theoretical quantity being 28.64. From these facts they declare that stearic and margaric acids are merely modifications of the same acid. They found, moreover, that, in the distillation of stearic acid, the greater part passes over without being decomposed; the same observation had previously been made by Chevreul on heating the acid *in vacuo*.

**Stearin.**—Arzbächer(3) has published an investigation of two varieties of stearin; (A) prepared from beef-suet, and fusing at  $47^\circ$ ; (B) from mutton-suet, fusing at  $50^\circ$ . The suet, fused in the water-bath, was agitated with ether, which, after cooling, was poured off from the crystals, the latter were pressed out, and several times submitted to the same treatment. The preparations thus obtained from the two varieties of suet were of a brilliant white colour, pulverisable, and fused at  $60^\circ.6$ . In the combustion of the stearin oxygen was employed in the last stage of the operation.

Carbon.	Hydrogen.	Oxygen.	
A. 78.62 to 78.95	12.22 to 12.43	8.83 to 9.19	found.
78.74	12.39	8.87	calculated from the formula $C_{142}H_{134}O_{12}$ .
B. 76.18 to 76.68	12.17 to 12.50	11.03 to 11.54	found.
76.21	12.34	11.45	calculated from the formula $C_{142}H_{138}O_{16}$ .

(1) *Recherches sur les Corps Gras*, 74.

(2) Laur. and Gerh. C. R. 1849, 337; *Compt. Rend.* XXVIII, 400 (in abstr.); *Ann. Ch. Pharm.* LXXII, 272.

(3) *Ann. Ch. Pharm.* LXX, 239; Laur. and Gerh. C. R. 1849, 343. Laurent and Gerhardt in their *Compt. Rend.* consider, in reference to the formula they have deduced for stearic acid, that the stearin from mutton-suet is more probably expressed by the formula  $C_{74}H_{70}O_8 = C_6H_8O_6 + 2 C_{34}H_{34}O_4 - 6 HO$ , which requires 76.8 per cent of carbon, 12.1 hydrogen; and that the stearin from beef-suet contains 2 equivs. of  $HIO$  less. ( $C_{74}H_{68}O_6$  requires 79.2 per cent of carbon, and 12.1 hydrogen.)

Stearin.

According to these formulæ, the stearin obtained from beef-suet consists of 1 equiv. of glycerin + 2 equivs. of stearic acid—8 equivs. of water, and that prepared from mutton-suet of 1 equiv. of glycerin + 2 equivs. of stearic acid—4 equivs. of water.

.According to Heintz(1), if stearin prepared from mutton-suet be enclosed in a small capillary tube and heated in a water-bath it becomes perfectly transparent at a temperature of from  $51^{\circ}$  to  $52^{\circ}$ , at a higher temperature opalescent, and at about  $58^{\circ}$  again, as originally, opaque; between  $62^{\circ}$  and  $62^{\circ}\cdot25$  it fuses. A thin plate of stearin becomes perfectly transparent without changing its form when immersed in water at a temperature of from  $51^{\circ}$  to  $52^{\circ}$ .

**Fatty Acids in the Oil of *Bassia*.**—Hardwick(2) has investigated the fatty acids contained in the oil of *Bassia latifolia*. This oil has a yellow colour, but is slowly bleached when exposed to the light; it smells feebly, has the consistence of butter, and fuses at from  $27^{\circ}$  to  $29^{\circ}$ . By spirits of wine of 0·84 sp. gr. it is scarcely affected, and is only slightly soluble in absolute alcohol; in ether, however, it is readily soluble, and on distillation it yields a large quantity of acrolein. The oil was saponified by dilute solution of soda, the soap separated by common salt and decomposed by hydrochloric, or better by tartaric acid. The mixture of fatty acids thus obtained, fusing at  $44^{\circ}\cdot5$ , was strongly pressed, and the residue repeatedly recrystallised from alcohol till the fusing-point remained constant at  $57^{\circ}\cdot2$ . This product, when treated with coal-tar-naphtha, pyroxylic spirit, or oil of turpentine, suffered no farther decomposition, but when several times recrystallised from ether the fusing-point rose to  $70^{\circ}\cdot5$ , where it remained constant. *Bassic acid* obtained in this manner is a white crystalline substance, whose alcoholic solution reddens litmus paper; its composition is expressed by the formula  $C_{36}H_{36}O_4$ ; when carefully heated in a bath of metal it distils over without being materially altered. Its salts have the composition  $RO$ ,  $C_{36}H_{35}O_3$ . The potassa-salt was prepared by boiling the acid with carbonate of potassa, evaporating to dryness, and extracting the salt with alcohol; it crystallises from the alcoholic solution in small needles, and forms, with water, a gelatinous mass. The silver- and baryta-salts were obtained as white precipitates by adding to the alcoholic solution of the potassa-salt nitrate of silver and chloride of barium. If chlorine be continuously passed into bassic acid which is kept in a bath of boiling water, the fused acid slowly thickens and solidifies on cooling to a readily pulverisable acid body which is saponified by potassa, and forms insoluble salts with protoxide of silver and with baryta. After the action of the chlorine had been continued for several weeks, the composition of the product was found to be  $C_{36}H_{26}Cl_{10}O_4$ ; Hardwick

(1) Berl. Acad. Ber. 1849, 222; J. Pr. Chem. XLVIII, 382; Instit. 1849, 390.

(2) Chem. Soc. Qu. J. II, 231; Ann. Ch. Pharm. LXXII, 268.

terms it *Chlorobassic acid*. The author attempted to free the portion of the mixture of acids, which was more soluble in ether, from bassic acid by repeated crystallisation from ether; the solution was evaporated when the successive crops of crystals assumed a constant fusing-point, and the residue fusing at from  $54^{\circ}$  to  $55^{\circ}$ , submitted to farther purification by distillation in a metal-bath; the distillate being freed from liquid carbohydrogens by alcohol. It then fused at from  $55^{\circ}\cdot 5$  to  $56^{\circ}\cdot 7$ , and had a somewhat waxy appearance. The composition of this acid and of its silver-salt agreed with that of palmitic acid ( $C_{32}H_{52}O_4$ ); it has, however, a different fusing-point. Hardwick considers it probable that the acid which is more soluble in ether has the composition  $C_{30}H_{50}O_4$ , and that the specimen which he prepared was contaminated with bassic acid.

Fatty acids  
in the oil  
of bassia.

**Shea-Butter and Chinese Vegetable Tallow.**—R. D. Thomson and E. T. Wood(1) have investigated the so-called shea-butter which is obtained by exhausting with boiling water the kernel of the fruit of a tree growing in Western Africa, and said to have a remarkable similarity to the American oak. They consider it to be identical with the so-called galam-butter, which is obtained from a species of *Bassia*. Shea-butter becomes soft at  $35^{\circ}$ , and at  $43^{\circ}\cdot 3$  fuses to a clear liquid. It is perfectly soluble in cold ether, and nearly so in hot alcohol; the solutions after evaporation or dilution with water deposit crystalline needles. By saponifying the substance with potassa, separating the soap by means of salt, and decomposing with tartaric acid, a fatty acid was prepared, which, after repeated recrystallisation from alcohol, and pressing between folds of paper, was obtained in nacréous plates which fused at a temperature of  $61^{\circ}\cdot 1$ . Its analysis, as well as that of its silver-salt, proved it to be margaric acid.—Chinese vegetable tallow obtained from the seeds of *Stillingia sebifera* fuses at about  $26^{\circ}\cdot 7$ ; by the above-mentioned process an acid was prepared therefrom which became perfectly liquid only at  $67^{\circ}\cdot 8$ ; this acid is considered by Thomson and Wood to be a mixture of a large quantity of margaric acid, with a minute portion of stearic acid.

**Oxidation of the Volatile Products of the Distillation of Fats.**—

F. C. Schneider(2) has investigated the bodies which are formed by the oxidation of the volatile products of the distillation of rape-oil. In order to remove the acrolein and the acids it might contain, the volatile liquid was digested with oxide of silver and then distilled

(1) Phil. Mag. [3] XXXIV, 350; J. Pr. Chem. XLVII, 237; Ann. Ch. Pharm. LXXXII, 273.

(2) Ann. Ch. Pharm. LXX, 107; Wien Acad. Ber. May, 1849, 307 (in abstr.); Chem. Gaz. 1849, 334.



Oxidation  
of the vola-  
tile pro-  
ducts of  
the distil-  
lation of  
fats.

with water; finally it was rectified by itself and dried over chloride of calcium. The distillate thus purified is free from colour and of penetrating odour, resembling that of acrolein. By exposure to the atmosphere and also by remaining for some time in closed vessels it assumes a yellow colour; the boiling-point of this compound rises from  $72^{\circ}$  to  $175^{\circ}$ . The average numbers obtained by analysis were 86.3 per cent of carbon, 12.0 hydrogen, 1.7 oxygen.—In oxidising this body by nitric acid, the apparatus is arranged in such a manner as to allow the vapours which are evolved to flow back again to the retort; after the operation is ended—which is known by the acid producing no farther action even at the boiling temperature—the liquid separates into two layers, one being lighter, oily, and of a dark colour; the other heavier, aqueous, and colourless. On addition of a farther quantity of water, a brownish-red oily acid mass deposits at the bottom of the vessel, having the odour of bitter almond-oil, and has been designated by Schneider as the nitro-compound. The aqueous liquid was neutralised by carbonate of potassa and crystallised. The mother-liquor separated from the crystals of nitrate of potassa was then decomposed by sulphuric acid, and the oily stratum which separated was employed for the preparation of baryta-salts; the liquid, after the removal of the oily stratum, was distilled with water and the acid distillate saturated with carbonate of soda, evaporated, and the crystals of nitrate of soda which were formed, together with their mother-liquor, were decomposed by nitrate of silver in order to prepare the silver-salts of the acids. By studying the baryta-salt the presence of *œnanthylic*, *caproic*, and *valeric* acids was established; the presence of *acetic*, *valeric*, *butyric*, and *propionic* acid was proved by examining the silver-salts. The nitro-compound above alluded to evolved red vapours and blackened at temperatures exceeding  $100^{\circ}$ , and from the carbonised mass some fatty acids were extracted by potassa. If the nitro-compound was rapidly distilled with water, the distillate was found to contain fatty acids; when fused with hydrate of potassa it evolved ammonia, and the residue, on addition of sulphuric acid, yielded hydrocyanic acid, and, on distillation, *œnanthylic*, *caproic*, and *valeric* acid. The nitro-compound is decomposed in the most perfect manner by passing into it ammonia-gas; there is formed a bright-red liquid from which a heavy oily stratum is deposited. The oily body resembles in odour and colour oil of bitter almonds, and the supernatant liquid contains *caprylic*, *œnanthylic*, and other lower fatty acids, descending in the series to *propionic* acid.—The more volatile distillate from rape-oil at the ordinary temperature is scarcely affected by a mixture of bichromate of potassa and sulphuric acid; the action, however, is very violent on application of heat; amongst the products of oxidation were found *propionic* and a large quantity of *acetic* acid.

**Sebacic Acid.**—Schlieper(1) has investigated the action of nitric acid upon sebacic acid. On boiling for two or three hours 1 part of sebacic acid with from 20 to 30 parts of nitric acid of 1·4 sp. gr., red vapours are evolved, but the sebacic acid appears to be little affected; it dissolves, however, in the nitric acid just before the temperature reaches the point of ebullition. In order to obtain sebacic acid perfectly white and pure, Schlieper recommends boiling it with from 5 to 6 times the quantity of nitric acid and then mixing the liquid with a large quantity of boiling water, when, on cooling, the sebacic acid crystallises out in a state of purity. By continued ebullition an extremely slow oxidation ensues; in order to oxidise 15 grms. of sebacic acid, it was necessary to continue the process eight days before the evolution of red vapours had entirely ceased. The liquid was evaporated to dryness, the residue dissolved in water and reduced by evaporation to the consistence of syrup. The syrup, when placed over sulphuric acid, solidified to a white, friable, crystalline acid which Schlieper found to be identical in composition and properties with pyrotartaric acid ( $C_5H_4O_4$ ). The determinations of the equivalent of the acid by means of the silver- and lead-salts did not, however, correspond to the equivalent of pyrotartaric acid, since the silver-salt yielded from 64·0 to 64·9 per cent of oxide of silver, 18·3 to 18·9 carbon, and 2·0 to 2·1 hydrogen; and the lead-salt from 72·7 to 73·2 per cent of protoxide of lead; the salts were prepared by precipitating the ammonia-salt with nitrate of silver and with neutral acetate of lead.

Sebacic  
acid.

**Acids in the Fatty Oil of Mustard-Seed.**—Darby(2) has published an investigation of the expressed oil of white and of black mustard-seed.—The fatty oil of white mustard was obtained by expressing the bruised and gently-warmed seeds of the officinal *Sem. Erucae*. It is a mobile, bright amber-yellow liquid which is inodorous, and possesses a bland taste; it is not solidified, even by the strongest cold of winter, but only thickened and rendered turbid; when heated, it evolves acrolcin. The oil was saponified by caustic soda; the soap, treated with water, in which it dissolved completely, was separated by chloride of sodium, and subjected several times to the same treatment. The soap which was freed in this manner from glycerin, was decomposed with dilute hydrochloric acid, and the liquid mixture of liberated acids washed, first with acidulated, then with pure water, and digested in a water-bath with finely-pulverised protoxide of lead. The lead-plaster thus obtained was exhausted by ether, until this solvent ceased to take up anything, and the residue treated with hydrochloric acid and alcohol; the chloride of

(1) Ann. Ch. Pharm. LXX, 121.

(2) Ann. Ch. Pharm. LXIX, 1; Chem. Gaz. 1849, 163.

Acids in  
the fatty  
oil of mus-  
tard-seed.

lead being then filtered off, and the alcohol distilled from the solution; the residuary acid was washed with warm water, and repeatedly recrystallised from alcohol, until the fusing-point remained constant. This point was at  $34^{\circ}$ , and the solidifying temperature at  $33^{\circ}$ . The acid, which Darby terms *Erucasie acid*, crystallises from the alcoholic solution in brilliant needles, and is represented by the formula  $C_{44}H_{43}O_4 = HO, C_{44}H_{41}O_3$ . Its salts have the formula  $RO, C_{44}H_{41}O_3$ . The silver-, lead- and baryta-salts were subjected to analysis; the silver-salt was prepared by precipitating an alcoholic solution of erucasie acid, supersaturated with ammonia, by nitrate of silver; it formed a cascos precipitate, which speedily assumed a darker colour, and possessed a constant composition only when it was washed, pressed between bibulous paper, and dried *in vacuo* over sulphuric acid. The lead-salt was obtained by heating a solution of erucasie acid, in absolute alcohol, with dry carbonate of soda, and precipitating the solution of the soda-salt thus obtained by an alcoholic solution of neutral acetate of lead. Finally, the baryta-salt was prepared by precipitating the alcoholic solution of the soda-salt with an alcoholic solution of acetate of baryta. The two latter salts are white precipitates, which are anhydrous when dried *in vacuo*. —The portion of the lead-plaster which was soluble in ether was mixed, after the ether had been previously evaporated, with hydrochloric acid and alcohol. After the chloride of lead had been filtered off, the alcohol was expelled by evaporation, and the crude oleic acid was employed for preparing a baryta-salt, according to the method of Gottlieb(1). This salt, in which the proportion of baryta remained constant after repeated recrystallisation, contained from 60.6 to 61.2 per cent of carbon, 9.8 hydrogen, 19.9 to 20.4 baryta, which corresponds most accurately with the formula  $BaO, C_{38}H_{36}O_4$ . The oleate of baryta,  $BaO, C_{36}H_{33}O_3$ , contains 61.8 per cent of carbon, 9.4 hydrogen, and 21.9 baryta. Darby leaves it undecided whether the fatty oil of white mustard does not contain an acid which differs from the oleic acid of the non-desiccative oils, or whether the former is mixed with another acid whose lead-salt is likewise soluble in ether.

By a similar mode of treatment, the expressed oil of the seeds of *Sinapis nigra* was found by Darby to contain stearic acid, erucasie acid, and a liquid fatty acid which appears to be identical with the above-mentioned acid obtained from white mustard; at all events, the baryta-salt of this latter acid, after frequent recrystallisation, likewise yielded 20.4 per cent of baryta. The stearic acid was first deposited from the solution of the mixture of acids separated from the insoluble portion of the lead-compound; after recrystallisa-

tion, the fusing-point was found to be  $70^{\circ}$ , and its baryta-salt to yield from 60.7 to 61.0 per cent of baryta, 10.1 to 10.5 hydrogen, and 22.99 baryta; subsequently the erucasic acid crystallised out of the mixture of the acids.

Amides,  
anilides  
and col-  
lateral  
matters.

Succinimide.

**Amides, Anilides and Collateral Matters. Succinimide.**—Laurent and Gerhardt(1) have examined the compounds of succinimide, or disuccinamide with oxide of silver. Succinimide (bisuccinate of ammonia—4 equivalents of water;  $\text{NH}_4\text{O}$ ,  $\text{C}_4\text{H}_2\text{O}_3 + \text{HO}$ ,  $\text{C}_4\text{H}_2\text{O}_3 - 4\text{HO} = \text{C}_8\text{H}_5\text{NO}_4$ ) is easily prepared according to Fehling's method, which consists in evaporating succinic acid with ammonia, and subliming the residue. When recrystallised from the smallest amount of hot alcohol it is deposited in rhombic tables, O P. P., the base of the pyramid having angles of  $67^{\circ}$  and  $113^{\circ}$ , and P : P in the base =  $112^{\circ}$ . The composition of the crystallised compound is  $\text{C}_8\text{H}_5\text{NO}_4 + 2\text{HO}$ , which is that of succinamic acid; it crystallises, however, from a concentrated solution of potassa, without giving rise to the formation of a salt. Succinimide unites with protoxide of lead, as has been pointed out by Fehling: the compound with oxide of silver is obtained by mixing a boiling concentrated, alcoholic solution of succinimide with some drops of ammonia, and subsequently adding nitrate of silver. The solution deposits, on cooling, four-sided prisms with pyramidal summits, containing  $\text{AgO}$ ,  $\text{C}_8\text{H}_4\text{NO}_3$ , which are soluble in ammonia in all proportions. They may be treated with potassa in the cold without evolving any ammonia; on ebullition, however, ammonia is rapidly disengaged. When gently warmed they yield a pungent oil, which solidifies into a crystalline mass; when rapidly heated they decompose with explosion. The ammoniacal solution of this compound deposits on spontaneous evaporation rectangular prisms  $\text{AgO}$ ,  $\text{C}_8\text{H}_4\text{NO}_3 + \text{NH}_3$ . If the silver-compound be boiled with water containing a few drops of ammonia it absorbs the elements of water, and is converted into succinamate of silver which, on evaporation, is obtained in small rhombic prisms of about  $75^{\circ}$ , more soluble in water than the original compound. When exposed to a rapidly increasing temperature this substance, which contains  $\text{AgO}$ ,  $\text{C}_8\text{H}_6\text{NO}_5$ , does not explode. If the solution be treated with hydrochloric acid, the filtrate contains nothing but succinimide.

**Sulphocarbamic Acid.**—Several years ago Zeise(2) examined the action of ammonia upon bisulphide of carbon, when he discovered sulphocarbonate of ammonia and another compound, which he considered as hydrosulphate of sulphocyanide of ammonium. Upon taking up this

(1) Laur. and Gerh. C. R. 1849, 108; J. Pr. Chem. XLVII, 71; Ann. Ch. Pharm. LXXII, 291.

(2) Schweigger's Journal, XLI, 98.

Sulpho-  
carbamic  
acid.

investigation again, Debus(1) has found that the latter compound is sulphocarbamate of sulphide of ammonium. The reaction of ammonia upon bisulphide of carbon in the presence of absolute alcohol gives rise to two different processes of decomposition, namely, 1. to the formation of sulphocarbonate of ammonia and of sulphocyanide of ammonium, and 2. to the direct combination of 2 equivs. of ammonia with 2 equivs. of bisulphide of carbon, sulphocarbamate of sulphide of ammonium being produced. In the concentrated solution at a temperature of from  $30^{\circ}$  to  $40^{\circ}$ , and with an excess of ammonia, the two former products of decompositions are chiefly formed, while the generation of the latter is promoted by the use of dilute liquids at from  $10^{\circ}$  to  $15^{\circ}$ , and of a large proportion of bisulphide of carbon. This compound, prepared according to Zeise's directions, crystallises in thin, lemon-yellow prisms,  $\text{NH}_4\text{S}, \text{C}_2\text{NH}_2\text{S}_3$ , faintly smelling of sulphide of ammonium, readily soluble in water, and somewhat less soluble in alcohol. By the addition of hydrochloric or sulphuric acid sulphocarbamic acid separates from this substance as a colourless oil, which is rapidly decomposed into products not farther examined, among which a considerable amount of hydrosulphocyanic acid is perceptible. Dilute solutions yield with hydrochloric acid a slight white flocculent precipitate, while bisulphide of carbon after several days is separated from the liquid. The supernatant portion has the odour of cyanic acid, and the presence of a large quantity of hydrosulphocyanic acid can be detected. When exposed to the moist atmosphere sulphocarbamate of sulphide of ammonium deliquesces into a turbid liquid, which appears to contain exclusively sulphocyanide of ammonium; potassa gives rise to sulphide and sulphocyanide of potassium, water and ammonia; chlorine, bromine, and iodine withdraw the ammonium with separation of a body containing  $\text{C}_2\text{NH}_2\text{S}_4$ . By decomposing the ammonia-salt with acetate of lead a white precipitate,  $\text{PbS}, \text{C}_2\text{NH}_2\text{S}_3$  is obtained, which on drying assumes a red colour; in a similar manner sulphate of zinc gives a white precipitate,  $\text{ZnS}, \text{C}_2\text{NH}_2\text{S}_3$ , and sulphate of copper a yellow precipitate  $\text{CuS}, \text{C}_2\text{NH}_2\text{S}_3$ . These compounds are very instable; when heat is applied, or when treated with the alkalis, they yield hydrosulphuric acid, hydrosulphocyanic acid, and a sulphide.

**Dinitro-diphenamic Acid.**—Laurent and Gerhardt(2) have investigated the action of sulphide of ammonium upon nitrophenessic acid ( $\text{C}_{12}\text{H}_4(\text{NO}_2)_2\text{O}_2$ ). On gently heating a solution of nitrophenessate of ammonia with sulphide of ammonium, a lively reaction is observed to take place after some minutes; the solution assumes a blackish tint, and deposits on cooling large blackish-brown needles. In order to purify this compound, the sulphide of ammonium is nearly decomposed by acetic acid, the liquid heated to ebullition, separated from the sulphur by filtration, and then evaporated to crystallisation. The

(1) Ann. Ch. Pharm. LXXIII, 26.

(2) Laur. and Gerh. C. R. 1849, 417.

crystals thus obtained are purified by recrystallisation from water. The new compound, *dinitro-diphenamic acid*, crystallises in six-sided blackish-brown needles, with 4 angles of  $131^{\circ}5$ , and 2 angles of  $97^{\circ}$ , which yield a yellow powder. The composition of these crystals is  $C_{24}H_{12}(NO_4)_3N_2O_4 + 4HO$ ; the water of crystallisation escapes between  $100^{\circ}$  and  $110^{\circ}$ . The formation of this acid depends upon the replacement in nitrophenessic acid of 2 equivs. of  $NO_4$  by 2 equivs. of  $NH_2$ ;  $C_{24}H_8(NO_4)_4O_4$  becoming  $C_{24}H_8(NO_4)_3(NN_2)_2O_4 = C_{24}H_{12}(NO_4)_2N_2O_4$ . Dinitro-diphenamic acid is but slightly soluble in cold water, easily soluble in alcohol and ether; when heated, it first loses its water of crystallisation, then fuses and yields some colourless plates and a brown oil, a charred residue remaining behind. With ammonia it forms a dark-red solution, from which the ammonia escapes completely upon evaporation. With potassa a dark brownish-red solution is obtained, depositing on spontaneous evaporation warty crystals of the potassa-salt,  $KO, C_{24}H_{11}(NO_4)_2N_2O_3$ . The solution of the ammonia-salt gives with acetate of baryta reddish-brown needles, slightly soluble in water, but with lime-salts small needles after some time, with acetate of lead a brownish orange-coloured precipitate, with acetate of copper a greenish-yellow, and with nitrate of silver a dark brownish-yellow precipitate; if hot solutions be employed, the latter may be obtained in small crystalline plates having, when dried at  $100^{\circ}$ , the composition  $AgO, C_{24}H_{11}(NO_4)_2N_2O_3$ .

A. W. Hofmann(1) has communicated a more detailed investigation of several derivatives of aniline, the existence of which he had pointed out at an earlier period(2).

**Carbamide-Carbanilide.**—The action of chloride of cyanogen upon aniline varies according to the complete absence or presence of water. In the former case, hydrochlorate of melaniline(3) only is formed; while in the latter, together with melaniline, *carbamide-carbanilide* is produced. This substance, which Hofmann designates in other memoirs by the abbreviated term *carbanilamide*, is contained in the liquid from which the melaniline is precipitated by potassa, and may be obtained by evaporation, when it is deposited in form of acicular crystals, having usually a slightly reddish tint. If aniline be treated with an aqueous solution of chloride of cyanogen, as obtained by passing chlorine into hydrocyanic acid, large quantities of the acicular crystals are formed; together with hydrochlorate of aniline and traces of melaniline. The same compound may be obtained moreover by mixing solutions of sulphate or hydrochlorate of aniline with cyanate of potassa, when the whole liquid solidifies after some hours into a crystalline mixture of

(1) Chem. Soc. Qu. J. II, 36; Ann. Ch. Pharm. LXX, 129.

(2) Ann. Ch. Pharm. LIII, 57; LVII, 131, 265; LXVII, 156.

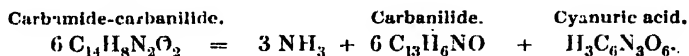
(3) Annual Report for 1847-8, 1, 508.

Carbamide-carbanilide.

carbamide-carbanilide with the potassa-salts of the acids just mentioned, from which it may be separated by crystallisation, being slightly soluble in cold and readily soluble in boiling water. Carbamide-carbanilide may be finally prepared by *slowly* passing the vapour of hydrated cyanic acid, as obtained in the distillation of cyanuric acid, into anhydrous aniline, which has to be kept cool in order to avoid the formation of a secondary product of decomposition insoluble in water (carbanilide). The composition of carbamide-carbanilide is  $C_{14}H_8N_2O_2$ ; in the two latter processes it is formed by the direct union of the constituents ( $C_{12}H_7N + HC_2NO_2 = C_{14}H_8N_2O_2$ ); in the reaction of chloride of cyanogen upon aniline in the presence of water, according to the equation  $2 C_{12}H_7N + C_2NCl + 2 HO = C_{12}H_7N, HCl + C_{14}H_8N_2O_2$ . — Hofmann found that by treating ammonia with chloride of cyanogen, no analogous exchange of oxygen for chlorine takes place, inasmuch as in the latter reaction he could not produce any urea. Carbamide-carbanilide is readily soluble in alcohol and ether; it may be heated to ebullition with dilute acids and alkalis, without undergoing any decomposition; on boiling however with concentrated potassa, or more readily on fusion with the hydrate, ammonia and aniline are evolved, carbonate of potassa remaining behind ( $C_{14}H_8N_2O_2 + 2(HO, KO) = NH_3 + C_{12}H_7N + 2(KO, CO_2)$ ). It is soluble in cold concentrated sulphuric acid, apparently without decomposition; on gently warming however, a lively evolution of carbonic acid ensues, sulphate of ammonia, sulphanilic acid, previously obtained by Gerhardt(1) by the action of concentrated sulphuric acid upon several anilides, remaining in solution ( $C_{14}H_8N_2O_2 + 3(HO, SO_3) = 2 CO_2 + H_4NO, SO_3 + C_{12}H_7NS_2O_6$ ). The formation of carbamide-carbanilide, in the action of cyanic acid upon aniline, induced Hofmann, when first he discovered this body, to consider it as a compound analogous to urea, and to propose the name *anilo-urea* (urea  $NH_3, HC_2NO_2$ , anilo-urea  $C_{12}H_7N, HC_2NO_2$ ); but the deportment of this compound with acids, with which it cannot be combined, discountenanced this view. (For the description of a substance having the same composition as carbamide-carbanilide, and possessing moreover the faculty of uniting with acids, we refer to page 245.) Hofmann now regards the body in question as a representative of a new class of compounds, consisting of simple and conjugated amides, namely, as a combination of the simple with the conjugated carbamide,  $NH_2, CO + C_{12}H_6N, CO$ . In confirmation of this view, he adduces that carbamide-carbanilide, when exposed to the action of heat, is actually split into its proximate constituents, one of which, carbanilide,  $C_{13}H_6NO$ , forms the principal product of the decomposition, while carbamide, at the temperature of the reaction, is converted

into farther products. If carbamide-carbanilide be heated beyond its point of fusion, a powerful evolution of ammonia takes place, the residue solidifying to a crystalline mass, which consists of carbanilide and cyanuric acid. From the residue the whole amount of cyanuric acid may be extracted by boiling with a large amount of water, in which carbanilide is but slightly soluble. The final result of the action of heat may be represented by the following equation :

Carba-  
mide-car-  
anilide.



**Carbamide-Nitrocarbanilide.**—On treating nitraniline with chloride of cyanogen, together with basic dinitromelaniline, an indifferent body is formed which is deposited in long yellow needles on cooling the solution of the crude product in boiling water. This substance is *carbanide-nitrocarbanilide*,  $\text{C}_{14}\text{H}_7(\text{NO}_2)\text{N}_2\text{O}_2$ . An analagous compound,  $\text{C}_{14}\text{H}_7\text{IN}_2\text{O}_2$  is generated, together with di-iodomelaniline, in the reaction of chloride of cyanogen upon iodaniline. It has not been analysed.

**Carbanilide**,  $\text{C}_{13}\text{H}_6\text{NO} = \text{C}_{12}\text{H}_6\text{N}, \text{CO}$ , is but slightly soluble in water. It is readily soluble in alcohol and ether; from the boiling alcoholic solution it is deposited in satiny needles. It is inodorous, but emits, on being heated, a suffocating odour. This substance fuses at about  $205^\circ$  and distils without alteration. The formation of carbanilide by rapidly passing the vapour of hydrated cyanic acid into aniline not cooled, has been mentioned at page 241. The simplest method of preparing it consists in exposing aniline to the action of phosgene-gas(1) free from chlorine; much heat is evolved, and the aniline solidifies at once to a crystalline mixture of the hydrochlorate and of carbanilide ( $2 \text{ C}_{12}\text{H}_7\text{N} + \text{COCl} = \text{C}_{12}\text{H}_7\text{N}, \text{HCl} + \text{C}_{12}\text{H}_6\text{N}, \text{CO}$ ), which may be separated by boiling water. The residuary carbanilide is purified by recrystallisation from alcohol. With concentrated sulphuric acid it yields pure carbonic and sulphanilic acids. When boiled with concentrated solutions, or fused with the hydrate of potassa, aniline and carbonate of potassa are formed. An analogous decomposition, although less completely, ensues, when moist carbanilide is rapidly exposed to a high temperature.

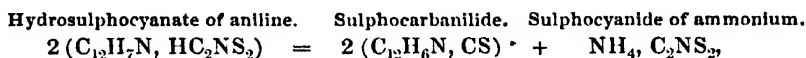
**Sulphocarbanilide.**—Hydrosulphocyanate of aniline is obtained by treating aniline with hydrosulphocyanic acid, as prepared by the action of hydrosulphuric acid on sulphocyanide of lead; the solu-

(1) Hofmann observed that phosgene gas may be readily obtained by passing carbonic oxide through pentachloride of phosphorus, which is thus reduced to the terchloride; it is, however, difficult to convert the last traces of carbonic oxide into phosgene gas. He recommends the use of this deportment for the qualitative discrimination of carbonic oxide in a mixture of gases, the odour of phosgene gas being easily recognisable.

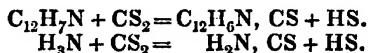


Sulpho-  
carbanil-  
lide.

tion deposits on evaporation oily globules which gradually solidify into a crystalline mass. This salt fuses when gently heated, and enters into a sort of ebullition; when exposed to a higher temperature hydrosulphuric acid and sulphide of ammonium are disengaged in considerable quantity; at the same time a colourless oil is collected in the receiver which solidifies to a semi-solid crystalline mass, while a slightly coloured resin-like residue remains in the retort, which consists of mcllon or mclam; this substance pertinaciously retains some compound of aniline. The distillate, when rectified, yields two layers, the lower one consisting of pure bisulphide of carbon, the upper one being a solution of sulphide of ammonium, while there remains in the retort a crystalline compound which was found to be *sulphocarbanilide*,  $C_{13}H_6NS=C_{12}H_6N, CS$ , that is carbanilide whose oxygen is replaced by sulphur (comp. Annual Report 1847 and 1848, I, 468). According to Hofmann this decomposition is represented by the following equation:—



the sulphocyanide of ammonium being converted at the temperature of the decomposition into ammonia, hydrosulphuric acid, bisulphide of carbon and mclam which, when heated more strongly, may split into ammonia and mcllon. A simpler method of obtaining sulphocarbanilide consists in acting with bisulphide of carbon upon aniline. A mixture of the two substances readily disengages hydrosulphuric acid, and solidifies gradually into a scaly crystalline mass. At the common temperature weeks elapse before this reaction is completed; at the heat of a sand-bath, the apparatus being so arranged as to allow the liquid to return to the seat of reaction, several days are required. The presence of alcohol promotes the process in a remarkable manner. As soon as the evolution of hydrosulphuric acid has ceased, the crystals of sulphocarbanilide are separated from the adhering bisulphide of carbon by ebullition, and purified by recrystallisation from alcohol. Hofmann points out that the action of bisulphide of carbon upon aniline is analagous to that upon ammonia, inasmuch as, according to Zeise's observations, an alcoholic solution of bisulphide of carbon, when exposed to the action of ammonia, readily yields sulphocyanide of ammonium, the formula of which is a multiple of sulphocarbamide ( $H_4N, C_2NS_2 = 2[H_2N, CS]$ ).



Sulphocarbanilide is only slightly soluble in water, but dissolves readily in alcohol and ether; the solutions are extremely bitter. It

fuses at  $140^{\circ}$ , and distils without decomposition. Dilute acids and alkalies have no effect upon this substance. It dissolves in cold concentrated sulphuric acid, apparently without decomposition; but when gently heated, carbonic and sulphurous acids are disengaged, and the solution deposits upon addition of water a crystalline mass of sulphanilic acid ( $C_{12}H_6N, CS + 2(HO, SO_3) = C_{12}H_7NS_2O_6 + CO_2 + HS$ ; the hydrosulphuric acid yields, in the presence of sulphuric acid, sulphurous acid and sulphur, which remain mixed with the sulphanilic acid). Sulphocarbanilide, when fused with hydrate of potassa, disengages pure aniline, carbonate of potassa and sulphide of potassium remaining in the retort ( $C_{12}H_6N, CS + 2(HO, KO) = C_{12}H_7N + KS + KO, CO_2 + HO$ ). If instead of the hydrate an alcoholic solution of potassa be employed, sulphocarbanilide is converted into carbanilide which is deposited on cooling in long needles ( $C_{12}H_6N, CS + KO = C_{12}H_6N, CO + KS$ ); the same change is effected by treating an alcoholic solution of sulphocarbanilide with protoxide of mercury.

**Carbanilamide**.—Chance(1) has investigated the action of sulphide of ammonium upon nitrobenzamide, which gives rise to the formation of a compound  $C_{14}H_8N_2O_2$ , having the same composition as Hofmann's carbamide-carbanilide (comp. page 241). For this substance Chance has proposed the name *carbanilamide*, or *anilurea*(2). The reaction of sulphide of ammonium, with an alcoholic solution of nitrobenzamide, is frequently very complicated; on the other hand, the change occurring in a boiling aqueous solution is very simple. The mixture is allowed to stand for 24 hours, filtered off from the separated sulphur, concentrated by evaporation, mixed again with water, filtered once more in order to remove the last traces of sulphur, and lastly exposed to spontaneous evaporation. The crystals, which are deposited, have to be recrystallised from water. Carbanilamide thus crystallised contains  $C_{14}H_8N_2O_2 + 2HO$ , the 2 HO escape between  $100^{\circ}$  and  $120^{\circ}$ ; its formation is represented by the following equation:  $C_{14}H_6(NO_2)NO_2 + 6H_2S = C_{14}H_8N_2O_2 + 4HO + 6S$ . When heated with soda-lime to a moderate temperature, half the amount of nitrogen contained in this compound is evolved in the form of ammonia, and the remainder is disengaged, only at a higher temperature, as aniline; hence two different stages have to be distinguished in this reaction, the first yielding anthranilate, or carbanilate of potassa (comp. Annual Report, 1847 and 1848, I., 468) ( $C_{14}H_8N_2O_2 + HO, KO = H_3N + KO, C_{14}H_6NO_3$ ), which in the second is converted into carbonate, with evolution of aniline [ $(KO,$

(1) Compt. Rend. XXVIII, 293; Laur. and Gerh. C. R. 1849, 177; J. Pr. Chem. XLVII, 140; Ann. Ch. Pharm. LXXII, 274.

(2) In Ann. Ch. Pharm. LXXII, 276, the name *anilamine-urea* has been proposed for this compound.

Carbanil-  
amide.

$C_{14}H_6NO_3 + KO, HO = C_{12}H_7N + 2 (KO, CO_2)$ . Concentrated sulphuric acid induces the same metamorphosis which, at page 242, has been mentioned for carbanide-carbanilide, namely, the formation of carbonic acid, sulphanilic acid, and sulphate of ammonia.

Chancel considers carbanilamide as the true anilo-urea. Carbanilamide is soluble in water, alcohol and ether; the alcoholic solution rapidly acquires a red colour, and seems to undergo decomposition. Crystallised carbanilamide fuses at  $72^\circ$ , the anhydrous compound only at  $100^\circ$ ; it is decomposed at a higher temperature leaving a carbonaceous residue. Carbanilamide combines with acids. The nitrate is but slightly soluble in water, it forms crystalline crusts or warty prisms, containing  $C_{14}H_8N_2O_2, HO, NO_5$ . Hydrochlorate of carbanilamide,  $C_{14}H_8N_2O_2, HCl$ , crystallises from an aqueous solution in small needles. The boiling solution of this salt yields with bichloride of platinum a double-salt,  $C_{14}H_8N_2O_2, HCl + PtCl_2$ , which crystallises on cooling in long orange-coloured prisms. Carbanilamide forms moreover a combination with nitrate of silver of the composition  $C_{14}H_8N_2O_2, AgO, NO_5$ , which is obtained on adding the latter to concentrated solutions of the former; it crystallises in needles, which are readily discoloured when exposed to the action of the light.

**Carbanilic Acid.**—In a later communication, Chancel(1) makes the following additional statement respecting the formation of carbanilic acid from carbanilamide. On boiling the latter with concentrated potassa until ammonia ceases to be evolved, and subsequently adding an excess of acetic acid, the liquid, unless very concentrated, yields no precipitate, but deposits upon cooling orange-yellow crystals of carbanilic acid,  $C_{14}H_7NO_4$ . This substance may be considered as bicarbonate of aniline — 2 equivs. of water ( $C_{12}H_7N, 2 HO, 2 CO_2 = C_{14}H_7NO_4 + 2 HO$ ); its compounds with the alkalies or alkaline earths when heated with potassa or baryta yield carbonates and aniline. Carbanilic acid itself, when mixed with spongy platinum and exposed to a high temperature, splits into carbonic acid and aniline. Sulphuric acid converts it into sulphanilic acid. Carbanilate of silver,  $AgO, C_{14}H_6NO_3$ , is almost insoluble in cold, but readily soluble in boiling water; the solution yields on cooling elongated plates, which may be heated to  $100^\circ$  without decomposition. Chancel believes that the acid obtained by the above process is identical both with Fritzsche's anthranilic and with Zinin's benzoic acid.

**Decompositions of Cyaniline.**—Farther inquiries into the action of acids and bases upon cyaniline,  $C_{14}H_7N_2$ , (2) have led Hofmann(3) to the following observations. Cyaniline is readily soluble in dilute

(1) Compt. Rend. XXVIII, 422.

(2) Comp. Annual Report, 1847-8, I, 506.

(3) Chem. Soc. Qu. J. II, 300; Ann. Ch. Phys. LXXIII, 180; Ann. Ch. Phys. [3] XXVIII, 429; Laur. and Gerh. C. R. 1850, 67.

hydrochloric acid; when treated with the concentrated acid it is converted into the hydrochlorate, which is insoluble in the strong acid. On adding fuming hydrochloric acid to a freshly prepared solution of cyaniline in dilute hydrochloric acid the hydrochlorate is separated as a scaly-crystalline precipitate; this salt cannot be obtained by evaporating the solution in dilute acid, the crystalline deposit formed under these circumstances contains scarcely a trace of cyaniline. This crystalline deposit yields to cold water chloride of ammonium and hydrochlorate of aniline (no oxalic or formic acid); the residue, when exhausted with boiling water, consists of oxanilide,  $C_{14}H_6NO_2$ , and the extract contains two substances which may be separated by evaporating it to dryness and treating it with alcohol. By this treatment oxamide is left, the alcohol dissolving a substance which is deposited on cooling, or on concentration, in white, hair-like, satiny flakes, soluble in ether, volatile without decomposition, and having, when repeatedly recrystallised from water, the composition  $C_{16}H_8N_2O_4 = C_{12}H_6N, C_2O_2 + H_2N, C_2O_2$ .

**Oxanilamide, or Oxamide-oxanilide.** — Hofmann describes this compound under the name *oxanilamide*, or *oxamide-oxanilide*; its constitution corresponds to that of carbamide-carbanilide mentioned at page 241. Oxanilamide is soluble in concentrated potassa, the solution becomes rapidly turbid, the substance being converted into oxalate of potassa, aniline and ammonia ( $C_{16}H_8N_2O_4 + 2 (HO, KO) = 2 (KO, C_2O_3) + C_{12}H_7N + H_3N$ ). Dilute sulphuric acid has no action upon oxanilamide; with concentrated sulphuric acid it yields equal volumes of carbonic acid and carbonic oxide, the solution retaining sulphanilic acid and sulphate of ammonia ( $C_{16}H_8N_2O_4 + 3 (HO, SO_3) = 2 CO_2 + 2 CO + C_{12}H_7NS_2O_6 + NH_4O, SO_3$ ). 1 equiv. of cyaniline ( $C_{14}H_7N_2$ ) + 2 HO + HCl contain the elements of 1 equiv. of chloride of ammonium, and 1 equiv. of oxanilide as well as of 1 equiv. of hydrochlorate of aniline and 1 equiv. of oxamide. Oxanilide, oxamide and oxanilamide (oxamide-oxanilide) are formed in nearly equal quantities, when cyaniline is treated with hydrochloric acid; it was found impossible to split oxanilamide into oxamide and oxanilide, either by the action of dilute acids or alkalies, or by continued ebullition. — Dilute sulphuric acid has precisely the same effect upon cyaniline. Hofmann directs attention to the fact that the deportment of cyaniline with acids confirms in a positive manner the correctness of the formula which he had proposed for this substance at an earlier period. — Cyaniline is soluble in concentrated sulphuric acid, with a violet colour; on gently heating the liquid, equal volumes of carbonic oxide and carbonic acid are evolved; if too much heat be applied, the proportion of carbonic oxide diminishes, sulphurous acid being disengaged at the same time; on cooling, the residuary liquid solidifies into a crystalline mass, containing sulphanilic acid and sulphate of ammonia. Bromine violently attacks cyaniline, the first product of

Oxanil-  
imide, or  
oxamide-  
oxanilide.

the action being probably tribromocyaniline, which is, however, rapidly decomposed by the influence of the hydrobromic acid formed, and converted into tribromaniline; the latter crystallises, especially if alcohol be present, in beautiful needles, upon the cooling of the liquid.—Cyaniline may be boiled with an aqueous, and even with an alcoholic, solution of potassa, without undergoing any change. When fused with hydrate of potassa, it disengages aniline and ammonia; the residue contains no oxalic acid, which at the temperature of the reaction is converted into carbonic acid, hydrogen being disengaged, as shown by experiment  $[C_{14}H_7N_2 + 2(HO, KO) + 2HO = C_{12}H_7N + H_3N + 2(KO, CO_2) + H]$ .

**Melanoximide or Oxamelanile.**—Hofmann(1), has studied, moreover, the decompositions of dicyanomelaniline  $C_{30}H_{13}N_5$ (2). This compound is also basic, although in a less degree than the bases derived from melaniline by substitution. Hofmann did not succeed in obtaining crystalline salts of this body. Dicyanomelaniline is soluble in acids, and is reprecipitated without change, if potassa or ammonia be added to the freshly prepared solution. The solution, however, rapidly undergoes decomposition, and then no longer contains a trace of the original substance. Hydrochloric acid of ordinary strength dissolves dicyanomelaniline, forming a clear, slightly yellow solution, which, however, becomes turbid after some minutes, depositing a yellowish precipitate, and retaining chloride of ammonium in solution. The yellowish precipitate is almost insoluble in water, but slightly soluble in boiling alcohol; it is deposited from the latter solution in the form of crystalline crusts which, at  $100^\circ$ , have the composition  $C_{30}H_{11}N_3O_4$ . This formula simply explains the formation of this substance, which is represented by the following equation,  $C_{30}H_{13}N_5 + 4HO + 2HCl = C_{30}H_{11}N_3O_4 + 2NH_4Cl$ . The actual amount of chloride of ammonium formed in this reaction was found to agree exactly with the quantity expressed in the given equation. The above formula represents binoxalate of melaniline—4 equivalents of water ( $C_{26}H_{13}N_3, 2HO, 2C_2O_3 - 4HO = C_{30}H_{11}N_3O_4$ ), and Hofmann considers it as a compound analogous to the imides or aniles, for which he proposes the name *Melanoximide* or *Oxamelanile*. The decompositions of this substance confirm this mode of viewing it; if an alcoholic solution of melanoximide be boiled with ammonia or potassa, crystalline melaniline is at once separated from the solution, which retains a considerable quantity of oxalic acid; by treating the alcoholic solution of the base with concentrated hydrochloric acid, the same products are obtained, together with another substance, not

(1) Chem. Soc. Qu. J. II, 307; Ann. Ch. Pharm. LXXIV, 1; Ann. Ch. Phys. [3] XXVIII, 431; Laur. and Gerh. C. R. 1850, 70 (in abstr.); Compt. Rend. XXVIII, 543 (in part); Instit. 1849, 129; J. Pharm. [3] XV, 397.

(2) Comp. Annual Report, 1847-8, 1, 511.

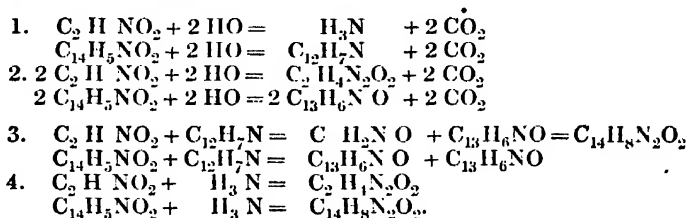
yet fully examined, which crystallises upon the cooling of the solution in long white needles. A solution of melaniline in dilute alcohol, especially after addition of some drops of ammonia, gives with nitrate of silver a yellow precipitate, the composition of which was, however, not constant.—Hofmann did not succeed in preparing melanoximide directly by heating binoxalate of melaniline(1); in this process a large quantity of carbonic oxide and carbonic acid is evolved, carbanilide subliming towards the end of the evaporation, and a viscid liquid remaining behind, which on cooling solidifies into a resin-like mass; the gases evolved exhibit in a remarkable manner a peculiar cyanic odour, frequently observed by Hofmann in the course of these investigations; but all attempts failed to separate from the gaseous mixture the body possessed of this odour.

Melanoxi-  
mide, or  
oxamela-  
nile.

**Anilo-cyanic Acid.**—The above substance was, however, isolated on subjecting melanoximide to destructive distillation. When heated, this compound fuses and evolves a considerable quantity of gas, containing a large proportion of carbonic oxide, and a small amount of carbonic acid; at the same time a yellowish liquid passes into the receiver, possessing a most powerful and suffocating odour which resembles those of aniline, cyanogen and hydrocyanic acid, inducing lachrymation in so high a degree that it is found necessary to collect the gas evolved during the distillation; towards the end of the operation radiated crystals of carbanilide sublime in the neck of the retort, while a slightly coloured resin-like residue remains behind. The distillate amounts to about 10 per cent of the melanoximide employed; it is decomposed by water, a fact which enforces the use of absolutely dry vessels, explaining at the same time why it cannot be procured by heating binoxalate of melaniline. The new substance is mixed with a certain quantity of carbanilide, from which it cannot be separated by fractional distillation; it may be purified, however, by cooling and freeing the liquid by filtration from the crystals which are thus separated. An additional rectification is sufficient to obtain it perfectly pure. In this state it is a powerfully smelling, colourless mobile liquid, heavier than water, highly refractive, boiling between 178 and 180°, and having the composition  $C_{14}H_5NO_2$ . Hofmann denominates this substance *Anilo-cyanic acid*, since its formula stands to that of aniline in the same relation which the formula of cyanic acid  $C_2HNO_2$  bears to that of ammonia. In fact the decompositions of anilo-cyanic acid are perfectly analogous to those of cyanic acid; 1. Cyanic acid, when acted upon by acids and alkalis, is converted into ammonia and carbonic acid; in a similar manner anilo-cyanic acid on treatment with potassa or hydrochloric acid yields aniline and carbonic acid; by concentrated sulphuric acid it is

Anilo-  
cyanic  
acid.

converted into sulphanilic acid; 2. Cyanic acid by absorbing the elements of water becomes carbonic acid and urea (bicarbamide); an analogous change is observed with anilo-cyanic acid which, when treated with water, especially at the boiling temperature, is converted into carbanilide  $C_{13}H_6NO$ , and carbonic acid; 3. Cyanic acid gives with aniline carbamide-carbanilide ( $C_2HNO_2 + C_{12}H_7N = C_{14}H_8N_2O_2$ ) (comp. p. 442), anilo-cyanic acid yields carbanilide; 4. Cyanic acid and ammonia form urea, anilo-cyanic acid and ammonia give carbamide-carbanilide. These various decompositions are represented by the following equations:

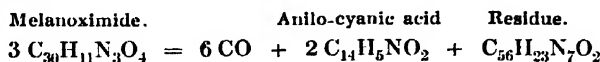


Anilo-cyanic acid dissolves in the various alcohols with evolution of heat; on cooling the solution deposits crystals containing the elements of 1 equiv. of aniloycyanic acid, and 1 equiv. of the alcohol. These substances are analogous to the compounds resulting from the action of cyanic acid upon the alcohols, which are known under the name of urethanes.

In order to obtain a more correct view regarding the action of heat upon melanoximide, which gives rise to the formation of anilo-cyanic acid, Hofmann has submitted melaniline itself to the same process. This substance may be heated to  $100^\circ$  without being altered, it fuses, however, between  $120^\circ$  and  $130^\circ$ , and is decomposed at about  $170^\circ$ . At first aniline alone is evolved, which is, however, soon accompanied by ammonia, even if the temperature be maintained at this point; on heating more strongly this gas is disengaged in considerable quantity. In the retort remains a transparent yellowish resin-like substance, insoluble in water; this substance is but slightly soluble in alcohol, forming a turbid liquid which filters with difficulty. The amount of carbon and hydrogen contained in a residue, in the preparation of which only traces of ammonia had been evolved, was found to agree with the formula  $C_{54}N_{25}N_7$ , i. e., 3 equivs. of aniline + 1 equiv. of the compound  $C_{18}H_4N_4$ , representing the mellon of the aniline-series. The quantity of nitrogen in the residuary products was not determined, the loss, however, which melaniline suffers, on being heated to  $170^\circ$ , was repeatedly ascertained, and found closely to agree with the formula of the compound  $C_{54}H_{25}N_7$ .—A similar constitution Hofmann is inclined to attribute to the residue which is left on heating melanoximide, this he assumes to contain  $C_{56}H_{23}N_7O_2$ , and to consist of 1 equiv. of anilomellon ( $C_{18}H_4N_4$ ), 2 equivs. of aniline ( $2C_{12}H_7N$ ), and 1 equiv.

of anilo-cyanic acid ( $C_{14}H_5NO_2$ ), an assumption which agrees pretty well with the result of experiment. Hence the principal part of the reaction might be thus expressed.

Anilo-  
cyanic  
acid.



Various secondary products however occur, such as carbonic acid and carbanilide, whose formation is likewise discussed by the author.

Hofmann points out, moreover, that anilo-cyanic acid may be considered as cyanate of phenyl,  $C_{14}H_5NO_2 = C_{12}H_5O, C_2NO$ ; however it cannot be obtained by distilling a mixture of cyanate of potassa and sulphophenylate of baryta. Lastly, he calls attention to the remarkable analogy between anilo-cyanic acid and cyanate of ethyl(1), both substances exhibiting exactly the same deportment when submitted to the action of potassa, ammonia and water.

**Non-existence of Anilo-Nitriles.**—Neutral salts of oxide of ammonium are converted by the loss of 2 equivalents of water into *amides*, by that of 4 equivalents, into *nitriles*; the acid salts become in the same manner either *amidogen-acids* or *imides*. In the aniline-series we have gradually become acquainted with the terms corresponding to the amides, amidogen-acids and imides, which have been described successively under the names anilides, anilidogen-(anilic) acids and aniles; substances corresponding to the nitriles of the ammonia-series have not as yet been obtained. A series of experiments on the action of anhydrous phosphoric acid upon salts of aniline and anilides, has led Hofmann(2) to the conclusion, that it is impossible to obtain aniline-substances corresponding to the nitriles. Oxalate of aniline loses 2 H<sub>2</sub>O, and is readily converted into oxanilide ( $C_{14}H_6NO_2$ ), however all attempts have failed to effect a farther removal of 2 H<sub>2</sub>O from this substance. When heated alone it is volatilised either without any decomposition, or with the formation of a very trifling quantity of anilo-cyanic acid ( $C_{14}H_5NO_2$ ); by the action of anhydrous baryta upon it, principally aniline is formed; with anhydrous phosphoric acid or chloride of zinc; it is charred, carbonic acid and carbonic oxide being at the same time disengaged. In a similar manner the attempt to prepare from benzoate of aniline an aniline-compound analogous to benzonitrile entirely failed. Hofmann remarks that Berzelius' theory, representing the organic bases as conjugated ammonia-compounds, which had been formerly(3) adopted by himself, does not account for the non-formation of the anilo-

(1) Comp. Annual Report, 1847 and 1848, II, 19.

(2) Chem. Soc. Qu. J. II, 331; Ann. Ch. Pharm. LXXIV, 33; Ann. Ch. Phys. [3] XXVIII, 448; J. Pharm. [3] XVII, 67; Compt. Rend. XXIX, 786 (in abstr.); Instit. 1849, 410.

(3) Comp. Annual Report, 1847 and 1848, I, 516.



Non-existence of anilino-nitriles.

nitriles, but that the reason becomes clear if we admit Liebig's view, in which these substances are considered as amidogen-compounds. According to the latter view the formulæ of oxalate and binoxalate of aniline assume the following shape,



On glancing at these expressions it becomes at once intelligible that the latter salt may lose either 2 HO or 4 HO, but that from the former only 2 HO can be removed without touching the compound atom  $C_{12}H_5$ . By actually abstracting 4 HO this compound atom is destroyed, and the product of decomposition can no longer belong to the aniline-series.

**Phenides.**—Laurent and Gerhardt(1) consider a class of bodies, which they term phenides, to be produced in a similar manner as ethers, amides, or anilides: in the formation of these bodies phenylic acid (phenole, phenic acid  $C_{12}H_6O_2$ ) comports itself precisely, like alcohol, ammonia or aniline, in the formation of the above-mentioned compounds.—Chloride of benzoyl and phenylic acid have no action upon each other in the cold, but on application of a gentle heat an evolution of hydrochloric acid takes place; the heat is continued, and chloride of benzoyl added as long as an action is observed; the product when allowed to remain solidifies to a crystalline mass, which is treated with a mixture of alcohol and ether, and yields needles of *benzophenide* on spontaneous evaporation. In general, however, a small quantity of an oily body is first deposited which appears to be benzoate of oxide of ethyl produced by the action of alcohol upon the excess of chloride of benzoyl. Benzophenide crystallises in pointed, colourless prisms of about  $80^\circ$ ; it fuses at  $60^\circ$ , boils at a higher temperature, and appears to distil over unchanged; its composition is  $C_{26}H_{10}O_4$ ; its formation is explained by the equation  $C_{14}H_5O_2Cl + C_{12}H_6O_2 = C_{26}H_{10}O_4 + HCl$ . It is insoluble in water, soluble in alcohol, and dissolves with facility in ether; it is insoluble in boiling aqueous solutions of the alkalis, but when heated with solid hydrate of potassa it forms therewith a compound from whose aqueous solution phenylic and benzoic acids are precipitated; by acids it is likewise decomposed, by concentrated sulphuric acid with the formation of phenylic and benzoic acids. Boiling hydrochloric or nitric acid appear to have no action upon it although the latter causes it to assume a yellow colour; bromine acts upon it with evolution of hydrobromic acid and the formation of readily fusible needles which are insoluble in water, but soluble in alcohol or ether; the composition of these crystals was found to correspond with the formula  $C_{26}H_{8\frac{1}{2}}Br_{1\frac{1}{2}}O_4$ ; they might, however, have contained still a

(1) Laur. and Gerh. C. R. 1849, 429; Compt. Rend. XXVIII, 170 (in abstr.); Arch. Ph. Nat. X, 232.

portion of undecomposed benzophenide. — *Dinitro-benzophenide*,  $C_{26}H_8(NO_4)_2O_4$  is obtained when nitrophenissic acid is intimately mixed with chloride of benzoyl and gently heated until hydrochloric acid ceases to be evolved; the undecomposed acid is extracted by a boiling dilute solution of ammonia, the residue washed with cold alcohol, and recrystallised from boiling alcohol. This compound crystallises in yellow rhombic plates, is insoluble in water, but dissolves in moderately hot ether. — *Trinitro-benzophenide*,  $C_{26}H_7(NO_4)_3O_4$ , is obtained in a similar manner by employing picric acid ( $C_{12}H_3(NO_4)_3O_2$ ); the product of the action of chloride of benzoyl is treated with cold alcohol till the latter passes off colourless, and the residue recrystallised from boiling alcohol. Trinitrobenzophenide is then deposited in golden-yellow rhombic plates which fuse at an elevated temperature and deflagrate when more strongly heated. On ebullition with ammonia it acquires a yellow colour, but the greater part remains undecomposed; when boiled with an aqueous solution of potassa it forms a dark reddish-yellow solution from which crystalline flocks are separated by acids. — If phenylic acid is brought into contact with pentachloride of phosphorus ( $PCl_5$ ) hydrochloric acid and oxichloride of phosphorus are immediately evolved; a thick, nearly odourless liquid is formed, which distils only at a higher temperature, the greater part being thereby decomposed. Laurent and Gerhardt believe that the product of this reaction, which they could not, however, obtain in a state of purity, is *chlorohydrophenide*,  $C_{12}H_5Cl$ , which stands in the same relation to phenylic acid as chloride of ethyl to alcohol. It does not dissolve in cold aqueous solution of potassa, but is slowly transformed thereby, as well as by pure water, into phenylic acid; the reaction is accomplished quickly by heat. — Nitrophenissic acid, when acted upon by pentachloride of phosphorus, appears to form an analogous compound in which 2 H are replaced by 2  $NO_4$ . Phenylsulphuric acid, discovered by Laurent(1), is said to stand in the same relation to phenylic acid as ethylsulphuric or sulphovinic acid stands to alcohol.

**Organic Bases.**—Laurent and Gerhardt(2) have endeavoured by a series of examples to prove that their views regarding the divisibility of the formulæ of organic compounds are borne out also by the organic bases. In some cases—as, for example, in those of quinine, cinchonine, and cyaniline—the formulæ in order to admit of the law of divisibility, have, in their opinion, to be doubled, and the salts of these bases which have hitherto been considered neutral to be considered as acid salts. Accordingly we should have to assume the existence not only of compounds containing 1 equiv. of base to 2

(1) Ann. Ch. Phys. [3] III, 195; Berzelius' Jahresber. XXII, 515.

(2) Laur. and Gerh. C. R. 1849, 160.

Quinine. equivs. of hydrochloric or nitric acid, but also of such as contain 1 equiv. of base to 2 equivs. of bichloride of platinum. With regard to the details we must refer to the original memoir.

**Quinine.**—Th. Wertheim(1), as appears from a preliminary communication to the Vienna Academy, adopts Liebig's formula  $C_{20}H_{12}NO_2$  for quinine as the true expression of its composition. His results were derived from the analysis of the following salts:—hydrosulphocyanate of quinine,  $C_{20}H_{12}NO_2$ ,  $HCyS_2$ ; a double-compound of hydrocyanate of quinine with cyanide of platinum,  $C_{20}H_{12}NO_2$ ,  $HCy$ ,  $PtCy + HIO$ ; another of hydrochlorate of quinine with bicyanide of platinum  $C_{20}H_{12}NO_2$ ,  $HCl$ ,  $PtCy_2$ ; a third of hydrosulphocyanate of quinine with cyanide of mercury,  $2(C_{20}H_{12}NO_2, HCyS_2) + HgCy$ ; and a fourth analogous compound with chloride of mercury,  $3(C_{20}H_{12}NO_2, HCyS_2) + 4HgCl$ . In the decomposition of quinine by hydrate of potassa, which takes place at from  $180^\circ$  to  $190^\circ$ , he finds that formic acid is produced and remains in combination with the potassa, whilst leucoline distils over. Hence he is inclined to consider quinine as a conjugated compound of hydrated oxide of methyl,  $C_2H_4O_2$ , or of a body isomeric therewith, and leucoline  $C_{18}H_8N$ ; or as a compound of the carbohydrogen  $C_2H_2$  with leucoline,  $C_{18}H_8N$ , and 2 equivs. of water. It is here to be remarked that leucoline, according to Laurent(2), contains 1 equiv. of hydrogen less than is represented in the above formula.

J. Büdker, jun.(3) obtained perchlorate of quinine by the mutual decomposition of sulphate of quinine and perchlorate of baryta; on evaporating the solution the salt was obtained in the crystalline form. According to the determination of Dauber(4) the crystals are rhombic pyramids with the terminal planes  $OP$ ; ( $P : P$  in the principal section of the base =  $149^\circ 46'$ , in the macrodiagonal =  $80^\circ 30'$ , in the brachydiagonal =  $107^\circ 32'$ . The ratio of the principal axis to the brachydiagonal and to the macrodiagonal =  $1 : 0.3417 : 0.4111$ ).—The alcoholic solution of the salt exhibits the most beautiful dichroism of blue and yellow, and solidifies by evaporation at the ordinary temperature over sulphuric acid to a brittle mass; the salt, when heated with water, forms oily drops which gradually dissolve: its composition, according to Büdker's analysis, is  $= C_{19}H_{11}NO_2, HO, Cl, O_7 + 7HO$ . The quantity of water of crystallisation, according to theory, is 19.7 per cent, whilst that found by experiment was 18.6 per cent; at  $160^\circ$  it fuses and loses all its water, and if heated to a higher temperature a violent explosion ensues; at  $100^\circ$ , however, it loses only 5 equivs. of water. At a certain stage of the concentration the solution deposits shining, regular rhombic tables, which exhibit the same dichroism as

(1) Wien. Acad. Ber. Nov. and Dec., 1849, 263; Ann. Ch. Pharm. LXXIII, 210.

(2) Annual Report, 1847 and 1848.

(3) Ann. Ch. Pharm. LXXI, 60.

(4) Ann. Ch. Pharm. LXXI, 65.

the former salt, but contain only 2 equivs. of water, and fuse alone only at  $210^{\circ}$ . The quantity of water found in this salt was 6.5 per cent, the calculated amount being 6.3 per cent.

Quinine.

J. van Heijningen(1) has discovered a new organic base in investigating a variety of quinoidine occurring in Dutch commerce; it is distinguished from ordinary quinine by its crystalline form, but principally by containing another proportion of water in the hydrate as well as in the salts. He terms this base  $\beta$  quinine, of which from 50 to 60 per cent, in addition to 3 per cent of quinine and from 6 to 8 per cent of cinchonine, was present in the quinoidine he investigated. The best mode of preparing it is to exhaust the quinoidine with ether, to dissolve the residue in dilute sulphuric acid, after evaporating the ether, and to precipitate the liquid with ammonia, after it has been decolorised by animal charcoal. The base thus separated, after being washed, is dissolved in ether, to which  $\frac{1}{10}$ th of its volume of 90 per cent alcohol is added, and the solution left to spontaneous evaporation, when a large quantity of the crystals of  $\beta$  quinine is deposited. It is obtained in a state of purity by washing with alcohol, and recrystallising from hot water.  $\beta$  quinine is separated from ordinary quinine, which Van Heijningen distinguishes as  $\alpha$  quinine, by precipitating the aqueous solution of its sulphate with ammonia, dissolving the washed precipitate in alcohol of 90 per cent, and leaving the solution gradually to evaporate, when the  $\beta$  quinine crystallises, whilst the  $\alpha$  quinine remains in solution.

$\beta$  quinine separates from its ethereal or alcoholic solution in large monoclinometric prisms which become opaque by exposure to the atmosphere, but do not crumble to pieces. It fuses at  $160^{\circ}$ , dissolves at  $8^{\circ}$  in 1500 parts of water, 45 parts of absolute alcohol, and in 90 of ether; at the boiling temperature, however, it dissolves in 3.7 parts of alcohol, and in 750 of water. The aqueous solution reacts feebly alkaline; it is coloured brown by tincture of iodine, and becomes somewhat milky on addition of concentrated solution of potassa; tannic acid produces in it a white precipitate. The anhydrous base has the same composition as the ordinary  $\alpha$  quinine for which Van Heijningen retains the formula  $C_{20}H_{12}NO_2$ . He found 74.08 per cent of carbon, 7.44 hydrogen, and 8.55 nitrogen. The hydrate of the base contains 2 equivs. of water, which it loses at from  $110^{\circ}$  to  $130^{\circ}$ . The quantity of water found was 10.8 per cent, the calculated quantity being 10.0 per cent. The hydrate of  $\alpha$  quinine contains 3 equivs. of water = 14.3 per cent.

$\beta$  quinine forms with acids neutral and basic salts, possessing a

(1) Scheik. Onderzoek. V, 4. Stuk, 233; Ann. Ch. Pharm. LXXII, 302; Jahrb. Pr. Pharm. XVIII, 367; Reper. Pharm. [3] IV, 88; Chem. Gaz. 1849, 319, 325; J. Pharm. [3] XVI, 280, 446.

Quinine.

strongly bitter taste; some of these salts—for example, the tartrate oxalate, and acetate—are more soluble than the corresponding salts of ordinary quinine; on the other hand, the nitrate and hydrochlorate are more difficultly soluble.—*Basic hydrochlorate of  $\beta$  quinine*,  $2\text{C}_{20}\text{H}_{12}\text{NO}_2, \text{HCl} + 2\text{HO}$ , separates in transparent white crystals, which are soluble in alcohol and in water, and contain 1 equiv. of water less than the corresponding salt of  $\alpha$  quinine; at  $120^\circ$  it loses 4.79 per cent of water, the theoretical quantity being 4.9 per cent. The platinum-double-salt,  $\text{C}_{20}\text{H}_{12}\text{NO}_2, \text{HCl}, \text{PtCl}_2 + 2\text{HO}$ , has the composition of the platinum-salt of  $\alpha$  quinine. 100 parts of dried  $\beta$  quinine absorb 22.5 parts of hydrochloric acid gas, and form when dissolved in water a crystallisable neutral salt.—*Basic sulphate of  $\beta$  quinine*,  $2\text{C}_{20}\text{H}_{12}\text{NO}_2, \text{SO}_3, 6\text{HO}(1)$  is very similar to the ordinary salt; at  $10^\circ$  it dissolves in 32 parts of absolute alcohol and in 350 parts of water, whilst the salt of ordinary quinine requires 740 parts of water, and moreover contains 7 equivs. of water.—*Nitrate of  $\beta$  quinine* readily separates in large, flat, vitreous crystals; *oxalate of  $\beta$  quinine*,  $\text{C}_{20}\text{H}_{12}\text{NO}_2, \text{C}_2\text{O}_3 + \text{HO}$ , forms readily soluble nacreous crystals, whilst the *acetate of  $\beta$  quinine* crystallises with difficulty.— $\beta$  quinine is said to have the same effect ordinary quinine in intermittent fevers.

Van Heijningen is of opinion that amorphous quinine does not exist, and that the substance known as such is merely  $\beta$  quinine, whose crystallisation is prevented by a substance which assumes a brown colour by exposure to the atmosphere. Winckler(2), however, by following the method of Van Heijningen for preparing  $\beta$  quinine, could not obtain an analogous crystalline base either from the amorphous sulphate of quinine he prepared at a former period, or from a mother-liquor of the quinine manufactory of Zimmer, obtained in the preparation of quinine from the genuine bark of *Cinchona regia*. The quinoidine of commerce accordingly varies both in regard to the nature as well as to the quantity of bases which it contains, the difference being dependent on the quality of the bark which has been employed in the preparation of quinine.

Van Heijningen(3), moreover, has published the following interesting observations proving the existence of another hydrate of quinine which was hitherto unknown.—When a solution of ordinary quinine in absolute alcohol is left to spontaneous evaporation, the base remains behind in the form of a resin, which encloses a number of crystalline needles; pure ether likewise leaves it in a resinous

(1) In the Ann. Ch. Pharm. LXXII, 304, it was pointed out that the formula  $2\text{C}_{20}\text{H}_{12}\text{NO}_2, \text{HO}, \text{SO}_3 + 6\text{HO}$ , for this salt is more correct and in accordance with the analysis. In the same manner the oxalate is represented by  $\text{C}_{20}\text{H}_{12}\text{NO}_2, \text{HO}, \text{C}_2\text{O}_3 + \text{HO}$ .

(2) Jahrb. Pr. Pharm. XVIII, 367.

(3) Scheik. Onderzoek. V, 319.

form, in which, however, no crystals can be perceived. Liebig and Harting have at a former period pointed out that quinine is deposited in needle-shaped crystals from a dilute solution in ammonia; these crystals are best obtained by leaving a dilute solution of sulphate of quinine, which is mixed with an excess of ammonia, to stand for some time, when delicate needles form upon the surface; these crystals when dried appear as an amorphous powder; from alcohol they crystallise no better than amorphous quinine. If, however, the freshly precipitated and well-washed quinine is spread out in the air and frequently moistened, the amorphous precipitate is slowly transposed into well-formed crystals, which, like  $\beta$  quinine, admit of being recrystallised from alcohol. The crystals, however, contain only 1 equiv. of water = 5.2 per cent; the quantity found by experiment was 5.06 per cent. The amorphous precipitate containing 3 equivs. (14.3 per cent) of water had therefore lost 2 equivs. of water in its transition to the crystalline modification. Van Heijningen terms this hydrate of quinine with 1 equiv. of water  $\gamma$  quinine; like the  $\alpha$  and  $\beta$  modifications, it forms basic and neutral salts, which are readily crystallisable. The basic sulphate contains only 1 equiv. = 4.71 per cent of water, the quantity found by experiment being 4.47 per cent. Hence we are now acquainted with three hydrates of quinine, whose different proportions of water are still recognisable in their sulphates.

**Extract of Cinchona.**—P. Blondeau(1) has published an investigation upon the quantity of extract yielded by different cinchona barks, according as they are extracted by boiling or infusing, as well as upon the amount of organic bases contained in the extracts thus prepared; he has endeavoured to prove that the grey and yellow cinchona barks yield more extract by decoction than by infusion; in the former case, the extract of course contains more matter which is insoluble in water; it is, however, not richer in alkaloids than the extract prepared by infusion, hence the latter method merits preference. The richest and best quality of extract is obtained by exhausting the bark with alcohol at a temperature of  $56^{\circ}$ , evaporating and dissolving the residue in cold water.

Maillet(2) and Schlotfeld(3) recommend the employment of the residue of cinchona bark, which has already been used for decoctions, extracts, &c., for preparing sulphate of quinine.

**Quinoidine.**—Bley(4) has observed an adulteration of quinoidine with sulphate and carbonate of soda and magnesia, together with a blackish-brown substance insoluble in water, alcohol and acids,

(1) J. Pharm. [3] XVI, 173.

(3) Arch. Pharm. [2] LX, 186.

(2) J. Chim Méd. [3] V. 36.

(4) Arch. Pharm. [2] LIX, 156.

Cinchonine.

amounting in all to about 27 per cent. Ohme(1) found in a specimen of commercial quinoidine 30 per cent of asphaltum; Walz(2) has detected from  $1\frac{1}{2}$  to  $2\frac{1}{2}$  per cent of finely divided copper.

**Cinchonine.**—By mutually decomposing of sulphate of cinchonine and perchlorate of baryta, and evaporating the solution to crystallisation, Bödeker, jun.(3) obtained large rhomboidal prisms, which were permanent in the air. The form of these crystals was determined by H. Dauber(4), according to whom, they belong to Naumann's diclinometric system. The crystals form rhombic prisms of  $25^{\circ} 47'$  and  $52^{\circ} 13'$ , with a right truncation of the acute prismatic edges, and with a double oblique terminal plane, which is inclined at  $56^{\circ} 15'$  towards one prismatic plane, towards the other at  $57^{\circ} 23'$ , and towards the plane of cleavage at  $80^{\circ} 54'$ . Perfect cleavage is observed parallel to the planes of truncation. The upper and lower terminal planes are not parallel, but differ in position as regards right and left. The salt is readily soluble in alcohol and in water, and exhibits also in dilute solution a dichroism of blue and yellow. It fuses at  $160^{\circ}$ , and loses 3.57 per cent of water of crystallisation, when farther heated it decomposes with explosion. The analysis corresponds nearest to the formula  $C_{19}H_{11}NO$ ,  $HO$ ,  $ClO_7 + HO$ .—With periodic acid cinchonine decomposes with separation of iodine; a similar deportment is exhibited by quinine, morphine and furfurine.

**Dibromocinchonine.**—The existence of dibromocinchonine  $C_{38}H_{20}Br_2N_2O_2$  has been proved by Laurent at an earlier period (comp. Annual Report for 1847-8, I, 476); he has now(5) given a process for preparing this base. An excess of bromine is poured upon acid hydrochlorate of cinchonine to which some water has been added; after the action has ceased, the excess of bromine is expelled by heat, and the product boiled with water; after filtration spirit of wine is added, the solution again heated, and neutralised with ammonia. On cooling the base is deposited in nacreous needles. It is colourless, insoluble in water, with difficulty soluble in alcohol, and decomposes at  $200^{\circ}$ . At  $160^{\circ}$  it loses no water. By allowing its aqueous solution to stand for several days in an open vessel, the hydrate of the base separates in rectangular octahedrons, which lose 4.2 per cent = 2 equivs. of water, at  $120^{\circ}$ . The acid hydrochlorate  $C_{38}H_{20}Br_2N_2O_2, 2 HCl$ , which is isomorphous with the acid hydrobromate of chlorocinchonine, is obtained by treatment with hydrochloric acid.

(1) Arch. Pharm. [2] LVIII, 148.

(2) Jahrb. Pr. Pharm. XIX, 270.

(3) Ann. Ch. Pharm. LXXI, 59.

(4) Ann. Ch. Pharm. LXXI, 66.

(5) Laur. and Gerh. C. R. 1849, 312; Ann. Ch. Pharm. LXXII, 305.

**Perchlorate of Morphine and of Codeine.** — Böderer, jun.(1), states, that by saturating morphine with aqueous perchloric acid, silky, fascicular, crystalline needles are obtained, which are pretty soluble in water and in alcohol; at 150° they fuse, and lose 8·34 per cent (theory 8·39) of water. The crystals are expressed by the formula  $C_{34}H_{19}NO_6, HO, ClO_7, + 4 HO$ .—Perchlorate of codeine is very similar to the preceding salt, but still more readily soluble. Both salts explode when heated.

Perchlorate  
morphine  
and of  
codeine.

**Papaverine.**—G. Merck(2) has published the mode of preparing, and the analysis of the papaverine which he discovered in opium (comp. Annual Report for 1847-8, page 482). For preparing this base, the brown resinous mass is employed which is obtained when the crude morphine, precipitated by soda from an aqueous extract of opium, is treated with spirit of wine; the brown extract is evaporated, the residue is digested with dilute acid, and the filtrate precipitated by ammonia. If the hydrochloric solution of this resin is mixed with acetate of potassa, a dark resinous body precipitates, which, after washing with water, yields the papaverine to ether. A second mode of preparation is to reduce the dried resin, by an equal weight of spirit of wine, to a syrup which solidifies to a crystalline mass after standing for several days at a temperature of about 30°; after recrystallisation and treatment with animal charcoal, it is converted into the hydrochlorate, from which all the narcotine may be separated by washing with cold water. Merck has analysed the pure papaverine, the hydrochlorate, and nitrate, as well as the platinum-salt. The several analyses led to the formula  $C_{40}H_{21}NO_8$ , for the base.—Papaverine may be taken in large doses, without producing any remarkable effect. By treatment with binoxide of manganese, binoxide of lead and sulphuric acid, or with moderately concentrated nitric acid, crystalline products are obtained, which, however, have not yet been accurately investigated.

**Piperine.**—Th. Wertheim(3), with the partial co-operation of Rochleder, has made an investigation upon the composition and the products of decomposition of piperine, which has thrown a clear light upon the constitution of this organic base. They obtained the platinum-salt of piperine in large, dark, orange-red crystals, by the spontaneous evaporation of alcoholic solutions of piperine and bichloride of platinum, previously mixed with concentrated hydrochloric acid. The crystals are readily soluble in spirit of wine, and are decomposed by a large quantity of water. Analysis of the compound, dried at 100°, agreed with the formula  $C_{70}H_{37}N_2O_{10}, HCl, PtCl_2$ .

(1) Ann. Ch. Pharm. LXXI, 63.

(2) Ann. Ch. Pharm. LXXIII, 50.

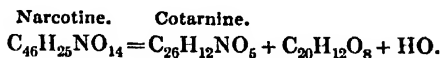
(3) Ann. Ch. Pharm. LXX, 58; Wien. Acad. Ber., 4. Hft., 151; J. Pharm. [3] XVII, 65; Laur. and Gerh. C. R. 1849, 375.



Piperine.

The crystallised piperine accordingly still contained 2 equivs. of water, and must be expressed by the formula  $C_{70}H_{37}N_2O_{10} + 2HO$ .—If piperine is intimately mixed with from 3 to 4 times its weight of a mixture of equal parts of hydrate of soda and hydrate of lime, and heated in an oil-bath to a temperature of from  $150^\circ$  to  $160^\circ$ , a colourless oil distils over without being accompanied by ammonia. This oil possesses the composition and properties of picoline,  $C_{12}H_7N$ , discovered by Anderson(1) in tar-oil: it is distinguished from this base merely by the property it possesses of coagulating albumin when placed in contact with an equal volume thereof, and allowed to remain a quarter of an hour.—From the residue which becomes of a dark cinnamon-brown colour, a brown resinous body is obtained, by successive treatment with cold water, then with alcohol, and finally with boiling dilute hydrochloric acid. The addition of water and a little hydrochloric acid to the solution of this body in absolute alcohol precipitates it in voluminous yellowish flocks, which dry up to a strongly electric powder. Proceeding from the above-mentioned decomposition of piperine, Wertheim calculates from the analysis of this body the formula  $C_{128}H_{67}N_3O_{20}$ , from which it appears that it might be formed by the elimination of 1 equiv. of picoline from 2 equivs. of piperine:  $2C_{70}H_{37}N_2O_{10} - C_{12}H_7N = C_{128}H_{67}N_3O_{20}$ . According to this it would appear that piperine itself is a conjugated compound of picoline with the body  $C_{58}H_{30}NO_{10}$ .—If the mixture of piperine and soda-lime is heated to  $200^\circ$ , ammonia, in addition to a large quantity of picoline, likewise passes over, and the residue is found to contain a non-nitrogenous body which is precipitable by acids in yellow flocks, whose composition Wertheim expresses by the formula  $C_{58}H_{27}O_{14}$ ; it might accordingly be formed from the compound  $C_{58}H_{30}NO_{10}$  by the elimination of  $NH_3$  and assumption of 4 O(2).

**Cotarnine and Narcogenine.**—Wertheim(3) has extended his views regarding the constitution of piperine to narcotine, and the bases derived therefrom, viz., cotarnine and narcogenine. He considers narcotine to be a conjugated base, and to consist of cotarnine and the non-nitrogenous body  $C_{20}H_{12}O_8$ .



Narcogenine might then be a conjugated compound of 2 equiva-

(1) Annual Report, 1847 and 1848, I, 482.

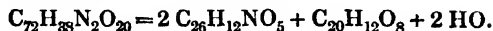
(2) Gerhardt (Laur. and Gerh. C. R. 1849, 376) considers the formula  $C_{70}H_{38}N_2O_{12} = C_{70}H_{36}N_2O_{10} + 2HO$  for piperine to be more correct; the platinum-double-salt would then be  $= C_{70}H_{36}N_2O_{10}, HCl, PtCl_2$ .

(3) Ann. Ch. Pharm. LXX, 71.

lents of cotarnine with the same non-nitrogenous body, and 2 equivalents of water.

Strychnine.

Narcogenine. Cotarnine.



**Strychnine.**—E. Ch. Nicholson and F. A. Abel(1), by a renewed investigation of strychnine and of a large number of its compounds, have established the true formula of this base. It is  $C_{42}H_{22}N_2O_4$ , as correctly calculated by Regnault at an earlier period.—*Hydrochlorate of strychnine*,  $C_{42}H_{22}N_2O_4$ ,  $HCl + 3 HO$ , like most of the other strychnine-salts, loses its water of crystallisation even *in vacuo* over sulphuric acid.—*Hydriodate of strychnine*,  $C_{42}H_{22}N_2O_4$ ,  $HI$ , is one of the most insoluble salts of the base.—In the *hydrosulphocyanate of strychnine* the proportion of acid was determined as sulphocyanide of silver, and that of the base by precipitation with ammonia; it is  $= C_{42}H_{22}N_2O_4$ ,  $HCyS_3$ .—*Neutral sulphate of strychnine*,  $C_{42}H_{22}N_2O_4$ ,  $HO$ ,  $SO_3$ , crystallises in large four-sided prisms; and the acid-salt,  $C_{42}H_{22}N_2O_4$ ,  $2 HO$ ,  $2 SO_3$ , in large slender needles.—*Nitrate of strychnine*,  $C_{42}H_{22}N_2O_4$ ,  $HO$ ,  $NO_5$ , forms colourless needles, which dissolve with a yellow colour when heated with concentrated nitric acid, and produce the nitrate of a nitro-base.—*Chromate of strychnine*,  $C_{42}H_{22}N_2O_4$ ,  $HO$ ,  $CrO_3$ , is difficultly soluble in water and in alcohol, and crystallises in orange-yellow needles.—*Oxalic acid* forms with strychnine a neutral salt,  $C_{42}H_{22}N_2O_4$ ,  $HO$ ,  $C_2O_3$ , and an acid-salt,  $C_{42}H_{22}N_2O_4$ ,  $2 HO$ ,  $2 C_2O_3$ .—*Bitartrate of strychnine*,  $C_{42}H_{22}N_2O_4$ ,  $2 HO$ ,  $C_8H_4O_{10}$ , crystallises in needles; the neutral salt is  $= 2 C_{42}H_{22}N_2O_4$ ,  $2 HO$ ,  $C_8H_4O_{10}$ . If strychnine is dissolved at the boiling temperature in bitartrate of potassa, neutral tartrate of potassa and bitartrate of strychnine are obtained.—*Hydrochlorate of strychnine and bichloride of platinum*,  $C_{42}H_{22}N_2O_4$ ,  $HCl$ ,  $PtCl_2$ , dissolves in nitric acid with formation of a new platinum-salt. *Hydrochlorate of strychnine and terchloride of gold*,  $C_{42}H_{22}N_2O_4$ ,  $HCl$ ,  $AuCl_3$ , is deposited from the alcoholic solution in bright orange-yellow crystals; *hydrochlorate of strychnine and protochloride of palladium*,  $C_{42}H_{22}N_2O_4$ ,  $HCl$ ,  $PdCl$ , is soluble in water and alcohol, and separates from the hot solution in dark-brown needles. *Strychnine and protochloride of mercury*,  $C_{42}H_{22}N_2O_4$ ,  $2 HgCl$ , is a white precipitate which is insoluble in water, alcohol, and ether. From its solution in sulphuric acid the compound  $C_{42}H_{22}N_2O_4$ ,  $HO$ ,  $SO_3$ ,  $2 HgCl$ , separates in a form which is only slightly crystalline; solution in hydrochloric acid yields the compound  $C_{42}H_{22}N_2O_4$ ,  $HCl$ ,  $2 HgCl$ . *Strychnine and cyanide of mercury*,  $C_{42}H_{22}N_2O_4$ ,  $2 HgCy$ ,

(1) Chem. Soc. Qu. J. II, 241; Ann. Ch. Pharm. LXXI, 79; Ann. Ch. Phys. [3] XXVII, 401; J. Pharm. [3] XVI, 305.

Strychnine.

is formed in the same manner as the corresponding compound with chloride of mercury; by mixing hydrochlorate of strychnine and cyanide of mercury, Nicholson and Abel obtained the compound  $C_{43}H_{23}N_2O_4$ , HCl, HgCy, whilst the salt prepared in a similar manner by Brandis contained 4 HgCy (Annual Report for 1847 and 1848, I, 483).—Strychnine enters into combination also with protochloride of platinum, iodide of mercury, and nitrate of suboxide of mercury, forming difficultly soluble salts which were not farther investigated.

**Perchlorate of Strychnine.**—Bödeker, jun.(1), states, that if boiling-hot solutions of sulphate of strychnine and perchlorate of baryta are decomposed in proper proportions, the solution deposits on cooling vitreous, rhombic prisms of perchlorate of strychnine,  $C_{42}H_{22}N_2O_4$ , HO,  $ClO_7 + 2 HO$ ; the salt loses its water of crystallisation completely at  $170^\circ$ , and explodes if more strongly heated. The quantity of water found was 3·8 per cent, which agrees with theory.—By dissolving strychnine in very dilute and warm periodic acid, lustrous rectangular prisms of *periodate of strychnine* are obtained, which explode violently when heated. The aqueous solution of this salt is decomposed by evaporation in the air.

**Brucine.**—Baumert(2) has published more in detail his experiments upon the decomposition of brucine by means of binoxide of manganese and sulphuric acid. The results have been already given in the Annual Report for 1847-8, I, 487.

**Perchlorate and Periodate of Brucine.**—By saturating dilute perchloric acid with brucine, Bödeker, jun.(3), obtained pale-yellow lustrous prisms of perchlorate of brucine, which are difficultly soluble in water and in alcohol, and lose at  $170^\circ$  5·4 per cent of water.—*Periodate of brucine* is yellowish, and similar to the strychnine-salt; it is readily soluble in hot water and in alcohol.—Both salts explode when heated.

**Perchlorate of Furfurine.**—Bödeker, jun., obtained, by dissolving furfurine in dilute perchloric acid, long, vitreous, very brittle crystals, which possessed a disagreeable, saline, bitter taste; according to Dauber(4), they belong to the right rhombic system,  $\infty P. \infty \bar{P} \infty. \bar{P} \infty (\infty P : \infty P = 72^\circ 33'$ ; the relation of the macrodiagonal to the brachydiagonal, and to the principal axis = 1 : 0·7338 : 0·4792; cleavage parallel to the brachydiagonal principal section). The salt is readily soluble in water and in alcohol, and contains 2 equivalents of water of crystallisation to 1 equivalent of base and 1 equivalent of acid; at from  $150^\circ$  to  $160^\circ$  it fuses, and loses 4·04 per cent of water, the theoretical quantity of water amounts to 4·65 per cent.

(1) Ann. Ch. Pharm. LXXI, 62.

(2) Ann. Ch. Pharm. LXX, 337; Chem. Gaz. 1849, 424.

(3) Ann. Ch. Pharm. LXXI, 62.

(4) Ann. Ch. Pharm. LXXI, 67.

**Caffeine.**—H. Heijnsius(1), in preparing caffeine (theine), submits old tea, which is unfit for use, at once to an increasing temperature in one of Mohr's benzoic acid apparatus; a considerable quantity of base sublimes, part of which is pure, and the remainder may be obtained in a state of purity by one recrystallisation from water.

Rochleder(2) has arrived at important results in the study of the decomposition-products of caffeine. If chlorine is passed into this base, made into a thick paste with water, until potassa no longer causes a precipitate of undecomposed caffeine, a liquid is obtained which produces on the skin a purple colour similar to that caused by alloxan, and assumes a beautiful indigo-blue colour with sulphate of protoxide of iron and an alkali. It contains, in addition to free chlorine and hydrochloric acid, the hydrochlorate of an organic base, a feeble acid, and an extremely volatile body, which excites a flow of tears, and induces head-ache, which could not, however, be isolated. On evaporating the liquid, the latter body is evolved, together with chlorine and hydrochloric acid; towards the end of the process crystals are formed of the above-mentioned acid, which Rochleder terms *Amalic acid* (from ἀμαλός, feeble). The acid is obtained in a state of purity by washing with cold water, boiling with absolute alcohol, and recrystallising from hot water. It is colourless, almost insoluble in absolute alcohol, and in cold water; it is difficultly soluble in hot water, and does not diminish in weight at 100°. It reddens litmus but very feebly, and forms with baryta, potassa, or soda, dark violet-coloured compounds which are not stable unless mixed with an excess of the acid. Ammonia colours this acid of a pure red, then of a dark violet, with formation of a crystallisable body, which dissolves in water with the same colour as murexide. When heated, amalic acid becomes of dark colour, and volatilises, whilst ammonia, an oily, and a crystalline body, are formed. The dissolved acid produces on the skin the same red spots as alloxan; it reduces silver-salt very readily, and when boiled with nitric acid yields a new crystallisable substance. Amalic acid has the formula  $C_{12}H_7N_2O_8$ .—If the solution from which the crystals of amalic acid have been separated is evaporated to  $\frac{1}{4}$ th of its volume, it solidifies to a crystalline mass, which is purified by pressing and recrystallising from hot water or alcohol. The large, leafy, unctuous crystals thus obtained are the hydrochlorate of an organic base, for which Rochleder adduced at first the formula  $C_2H_4N$  from the analysis of its platinum-salt; he assigned to it the name *formyline*, since it might be considered as a conjugated compound of ammonia with formyl.—

(1) Scheik. Onderzoek. V, 5. Stuk, 318; J. Pr. Chem. XLIX, 317.

(2) Ann. Ch. Pharm. LXIX, 120; LXXI, 1; Wien. Acad. Ber. February, 1849, 93; J. Pharm. [3] XVII, 74.

Caffeine.

A. Wurtz(1) has in the meantime pointed out that the base obtained by Rochleder, by decomposing caffeine, is nothing more than methylamine (page 271), of which he is the discoverer; and that, consequently, it has the formula  $C_2H_5N$ . He convinced himself that methylamine is formed on boiling caffeine with concentrated solution of potassa; the platinum-salt of the base thus prepared agreed with the formula  $C_2H_5N$ ,  $HCl$ ,  $PtCl_2$ .—Rochleder(2) likewise found, after he had become acquainted with Wurtz's investigation on methylamine, that his analysis agreed better with the formula adduced by the latter chemist; and he stated that formylamine was identical with methylamine, even before the above-mentioned experiments of Wurtz were published.

Rochleder considers caffeine to be a cyanogen-compound of the formula  $C_2N$ ,  $C_2H_5N$ ,  $C_{12}H_5N_2O_4$ . By heating it with an alkali it produces a metallic cyanide; this deportment is not exhibited under similar circumstances, either by quinine, cinchonine, morphine, or piperine. By the action of chlorine the cyanogen is decomposed, with formation of the above-mentioned body which attacks the eyes so severely; the base  $C_2H_5N$  combines with the hydrochloric acid, whilst the body  $C_{12}H_5N_2O_4$  is transformed into amalic acid  $C_{12}H_7N_2O_8$  by assuming 2 equivs. of oxygen and 2 equivs. of water. Amalic acid is likewise formed when theobromine is treated with chlorine. By farther treatment with chlorine, amalic acid gives rise to the formation of the body which has been described by Stenhouse under the name of *Nitrotheine*, as a product of the decomposition of caffeine by nitric acid. Owing to its similarity to cholesterin, Rochleder terms it *Cholestrophane*. The analyses made of this substance by Stenhouse and Rochleder lead to the formula  $C_{10}H_6N_2O_6$ . According to a subsequent communication of Rochleder(3), cholestrophane, when boiled with potassa, is decomposed into oxalic acid, carbonic acid, and a body possessing the odour of ammonia; he considers it probable that this latter substance is ethylamine  $C_4H_7N$ .

**Pelosine.**—Bödeker(4) has submitted to analysis the organic base discovered by Wiggers(5) in *Rad. Pareiræ*, and to which he assigned the name *Pelosine*. He obtained the pelosine from its solution both in alcohol and ether, always in the amorphous state, and of a white colour after being pulverised. The anhydrous base has the formula  $C_{36}H_{21}NO_6$ ; when left in contact with water it forms a

(1) J. Pharm. [3] XVII, 76; Compt. Rend. XXX, 9; J. Pr. Chem. XLIX, 406.

(2) Ann. Ch. Pharm. LXXIII, 56.

(3) Ann. Ch. Pharm. LXXIII, 123.

(4) Ann. Ch. Pharm. LXIX, 53; Chem. Gaz. 1849, 152.

(5) Ann. Ch. Pharm. XXIII, 81.

hydrate  $C_{36}H_{21}NO_6 + 3 HO$ , which loses all its water at  $120^\circ$  (calculated 8.27 per cent, found 8.21 per cent). The hydrochlorate of pelosine precipitated by dry hydrochloric acid gas from its ethereal solution, which is free from water and spirit of wine, is a white amorphous powder  $C_{36}H_{21}NO_6, HCl$ , which in the air assumes 2 equivs. of water, without becoming moist, and thus loses its pulverulent properties. The pale-yellow amorphous platinum-double-salt is  $C_{36}H_{21}NO_6, HCl, PtCl_2$ . Bichromate of potassa precipitates from hydrochlorate of pelosine flocky, light-yellow, neutral chromate of pelosine,  $C_{36}H_{21}NO_6, HO, CrO_3 + HO$ , which becomes darker on drying; when heated above  $100^\circ$  it rapidly decomposes into leucoline (quinoline), carbolic acid, whilst sesquioxide of chromium remains behind.

**Pelluteine**.—By the action of air and light upon pelosine, in the presence of water, it slowly assumes a yellow colour, with evolution of ammonia, and is transformed into a base termed by Bödeker *Pelluteine*, and which is no longer soluble in ether. By treatment with hot absolute alcohol which leaves behind it a body resembling humin, it is obtained in a state of purity. It separates as a flocky, brownish-yellow mass, which is distinguished from pelosine, besides being insoluble in ether, merely by the circumstance of its compounds being coloured of a darker yellow. An analysis of the base dried at  $100^\circ$  gave numbers corresponding with the formula  $C_{42}H_{21}NO_7$ ; the platinum-double-salt contained as a mean 17.84 per cent of platinum.

**Nitroharmaline**.—In the Annual Report for 1847-8, I, 490, we have mentioned the investigation of Fritzsche upon harmaline and its allied bases; his farther experiments(1), which are now before us, relate to the deportment of nitroharmaline towards protoxide of silver, petroleum, and hydrocyanic acid.

If a perfectly neutral nitroharmaline-salt is mixed with solution of protoxide of silver-ammonia containing no excess of ammonia, a gelatinous, yellowish-red precipitate is formed which on drying shrinks together, becomes brownish-red, and is decomposed readily by acids and ammonia. It is a compound of equal equivalents of protoxide of silver and nitroharmaline, and contains 30 per cent of protoxide of silver.—With nitrate of silver nitroharmaline forms two compounds, one of which separates in bright-yellow felted needles, the other in orange-yellow grains, when the alcoholic solution of the base is mixed with the silver-salt.—When a solution of nitroharmaline in petroleum is allowed to cool, it deposits, in addition to orange-yellow grains of the unchanged base, bright-yellow needles of a

(1) Petersb. Acad. Bull, VIII, 81; J. Pr. Chem. XLVIII, 175; Ann. Ch. Pharm. LXXII, 306.

Hydro-  
cyano-  
nitro-  
harmaline.

compound of nitroharmaline with petroleum; this compound is decomposed by ebullition with water, and admits of being dried in a water-bath without suffering change. By alcohol it is instantly decomposed into its constituents. It contains from 5.5 to 6.3 per cent of petroleum.

**Hydrocyano-nitroharmaline.**—Nitroharmaline forms a compound with hydrocyanic acid in the same manner as harmaline; the compound likewise exhibits a deportment similar to that of hydrocyano-harmaline. According to the analysis of Fritzsche it contains 8.85 per cent of hydrocyanic acid, corresponding to a compound of equal equivalents of the two, which requires 9.2 per cent of acid.—At 120° hydrocyano-nitroharmaline fuses without loss of weight to a resinous dark yellowish-brown mass which contains, in addition to a large quantity of undecomposed base, another body of which Fritzsche mentions little more than that it appears to have some similarity to a substance which is formed by heating a solution of nitroharmaline that has been partially precipitated with ammonia(1).

**Atropine.**—According to experiments made in the Hôtel-Dieu in Paris, Bouchardat and Stuart-Cooper(2) prefer the pure atropine to all other preparations of belladonna; they employ it in doses of 0.002 to 0.01 grm., either as an external or internal remedy. In order to prepare atropine, Bouchardat recommends to precipitate it by an aqueous solution of iodine in iodide of potassium, to decompose the precipitate by zinc and water, and to extract the base by alcohol after separating the protoxide of zinc by an alkaline carbonate.

**Conine.**—J. Blyth(3), in investigating the composition of conine, has arrived at results which differ from those obtained by Ortigosa(4). The crude conine, which appears to vary in the mixture of its constituents, has no constant boiling-point after separation of its water by means of hydrate of potassa. The portion passing over between 170° and 175° contains the greater part of the base; at a higher temperature it appears to be decomposed. Blyth assumes the boiling-point of conine to be between 168° and 171°, whilst Geiger found it to be at 150°, Christison at 188°, and Ortigosa at 212°. Blyth has communicated the following remarks on the properties of freshly distilled conine. It is a transparent, colourless oil of 0.878 sp. gr.; of penetrating, disagreeable odour which lasts for a long time; its vapour attacks the eyes. It is soluble in alcohol, ether, acetone, and in oils, but only slightly in bisulphide of carbon; it

(1) Gerhardt proposes (Laur. and Gerh. C. R. 1849, 346) the formula  $C_{28}H_{14}N_2O_2$  for *harmaline*,  $C_{28}H_{12}N_2O_2$  for *harmine*, and  $C_{26}H_{15}(NO_4)N_2O_2$  for *nitroharmaline*.

(2) From the Gaz. Méd. de Paris, 1848, 991, in Repert. Pharm. [3] II, 326.

(3) Chem. Soc. Qu. J. I, 345; Ann. Ch. Pharm. LXX, 73; Laur. and Gerh. C. R. 1849, 371.

(4) Ann. Ch. Pharm. XLII, 313.

exhibits only in the presence of water a transitory alkaline reaction upon vegetable colours; it coagulates albumin instantly.

Conine.

Conine dissolves sulphur with facility, but it does not appear to act upon phosphorus. It precipitates many metallic oxides from their salts, and dissolves oxide and chloride of silver very readily. From the analysis of the base, as pure as it was possible to obtain it, and of its platinum-double-salt, Blyth deduces the formula  $C_{17}H_{17}N$ ; it differs from the formula proposed by Ortigosa ( $C_{16}H_{16}N$ ) by containing 1 equiv. more of carbon and 1 equiv. more of hydrogen(1).

The following synopsis of the analysis of conine and of its platinum-double-salt exhibit such considerable variations that it is difficult to decide in favour of the one or the other formula; assuming, however, the proportion of platinum to be somewhat too low, the analysis of the platinum-double-salt by Ortigosa is most in favour of Gerhardt's formula,  $C_{16}H_{15}N$ .

CONINE.						
	Blyth.	Ortigosa.		$C_{17}H_{17}N$ .	$C_{16}H_{16}N$ .	$C_{16}H_{15}N$ .
C	75.11	74.83	74.30	76.7	76.2	76.8
H	13.07	12.17	11.98	12.8	12.7	12.0

PLATINUM-DOUBLE-SALT.							
	Blyth.		Ortigosa.		$C_{17}H_{17}N$ , HCl, PtCl <sub>2</sub> .	$C_{16}H_{16}N$ , HCl, PtCl <sub>2</sub> .	$C_{16}H_{15}N$ , HCl, PtCl <sub>2</sub> .
C	29.81	29.56	28.7	28.8	30.1	28.8	28.9
H	5.39	4.92	5.0	—	5.3	5.1	4.8
N	4.05	—	4.7	4.6	4.1	4.2	4.2
Pt	29.16	29.02	29.3	29.4	29.1	29.7	29.8

Chlorine rapidly decomposes conine with formation of a crystalline volatile compound which is readily soluble in water, alcohol and in ether.—Bromine produces with it an almost black mass, from whose aqueous solution, after being decolorised by animal charcoal and evaporated *in vacuo*, colourless crystals are deposited, which dissolve with facility in water and alcohol, and fuse at 100°. Analysis gave 48.52 per cent of carbon, and 8.98 per cent of hydrogen; the formula Blyth assumes for this compound is  $C_{17}H_{17}BrN$ , which requires 48.28 per cent of carbon and 7.57 per cent of hydrogen(2).—An alcoholic solution of iodine yields with conine a dark-brown precipitate which is soluble in water, alcohol, and in ether; it separates from these solutions in colourless crystals.—Most of the salts of conine are deliquescent, and difficultly crystallisable; the platinum-

(1) Gerhardt (Laur. and Gehr. C. R. 1849, 373) rejects both formulæ, and it appears with justice; he leaves it to farther investigations to decide whether the formula  $C_{16}H_{15}N$  he has proposed, is tenable or not.

(2) Gerhardt considers it probable that this compound is hydrobromate of conine.



Conine.

double-salt, which is readily soluble in hot alcohol, crystallises in four-sided prisms which fuse somewhat above  $100^{\circ}$ . Conine forms with protochloride of mercury a lemon-yellow compound, which is insoluble in water and ether, and is very readily decomposed; Blyth adduces for this compound the formula  $C_{17}H_{17}N, 4 HgCl$ .

Blyth has, moreover, studied the deportment of conine under oxidising influences; he found that butyric acid is invariably produced under these circumstances. It is formed by the resinification of the base in the air, and, in larger quantity, by the action of bichloride of platinum, of bichromate of potassa and sulphuric acid, of nitric acid, &c., upon conine. On boiling conine with bichloride of platinum, Blyth observed an evolution of carbonic acid. The formation of butyric acid he explains by the equation  $C_{17}H_{17}N + 8O = 2C_8H_7O_3 + NH_3 + CO_2$ ; if Gerhardt's formula for conine is correct, the evolution of carbonic acid is unessential, the equation would then be  $C_{16}H_{15}N + 4HO = 2C_8H_8O_4 + NH_3$ .

**Crotonine.**—Fr. Weppen(1) has proved that the *crotonine* obtained by Brandes from croton seeds is nothing but a compound of magnesia with a fatty acid.

**Volatile Bases obtained by Dry Distillation, Putrefaction, &c.**—Stenhouse(2) has subjected a number of vegetable substances rich in nitrogen to dry distillation, and has investigated the distillate, which contained a quantity of organic bases. The author was led to these experiments by the view that the organic bases of coal-tar owe their origin to the nitrogenous compounds originally existing in the plants from which the coal has been formed. The distillate was treated with hydrochloric acid, the hydrochloric extract boiled some time, and decolorised by animal charcoal; it was then supersaturated with lime or carbonate of soda and distilled. The liquid which passed over invariably contained, in addition to an abundance of ammonia, a larger or smaller quantity of oily organic bases, which were separated by fractional distillation. Up to the present time, Stenhouse has submitted to accurate investigation only one of the bases, obtained by the dry distillation of beans. This base was contained in the portion of the distillate passing over between  $150^{\circ}$  and  $155^{\circ}$ . It is lighter than water, and dissolves in from 6 to 7 times its volume; it is dissolved in every proportion by alcohol and ether. It possesses a peculiar aromatic odour, a burning taste resembling that of peppermint-oil, and remains perfectly colourless if excluded from light and air. With hydrochloric, nitric and sulphuric acid it forms salts which crystallise in prisms; the double salts it gives with bichloride of platinum and

(1) Ann. Ch. Pharm. LXX, 254.

(2) Ann. Ch. Pharm. LXX, 198; LXXII, 86; Phil. Mag. [3] XXXV, 534; Chem. Gaz. 1849, 389, 422; J. Pharm. [3] XVI, 456.

terchloride of gold are likewise crystallisable. From his analyses, which varied in the proportion of hydrogen between 8.18 and 7.77 per cent, Stenhouse has calculated the formula  $C_{10}H_6N$ ; which requires 7.49 per cent of hydrogen. The platinum-double-salt gave from 34.6 to 34.7 per cent of platinum; the formula  $C_{10}H_6N, HCl, PtCl_2$  requires 34.5 per cent.—In addition to beans, Stenhouse has subjected to dry distillation wheat, turf, and the entire plant of *Pteris aquilina*, and obtained from them pretty considerable quantities of organic bases; on the other hand, he found that oil-cake yielded a much smaller proportion, and hard wood scarcely traces of bases. He moreover convinced himself that nitrogenous vegetable or animal substances, such as beans, lycopodium, flesh, and bullock's liver, form organic bases by ebullition with caustic alkalies or dilute sulphuric acid; he has also shown that in the putrefaction of flesh a portion of its nitrogen, though a smaller one, passes over in the form of volatile organic bases. Aniline could not be detected in any of these products of decomposition.

Volatile  
bases ob-  
tained by  
dry distil-  
lation, pu-  
trefaction,  
&c.

**Aniline.**—T. S. Hunt(1) states, that a heated solution of nitrate of aniline, in moderately dilute nitric acid rapidly absorbs the vapour of nitrous acid with evolution of nitrogen and formation of a brown oily body soluble in ether, and which he considers to be carbolic acid. This body possesses the odour of castoreum; a strip of pine-wood when moistened with it assumes, by immersion in nitric acid, in the first place a blue, and then a brown colour. From its solution in caustic alkalies it is precipitated unchanged by nitric acid; at the boiling temperature it reduces nitrate of silver to the metallic state; with concentrated nitric acid it yields an acid, whose potassa-salt crystallises in difficultly soluble yellow needles which decrepitate when heated. Hunt assumes that the decomposition of aniline proceeds according to the following equation:  $C_{12}H_7N + NO_3 + HO = C_{12}H_6O_2 + N_2 + 2 HO$ . The same decomposition of the base is stated to take place when an aqueous solution of nitrite of silver is heated with salts of aniline.

**Homologues of Ammonia.**—When reporting upon the phosphorus-bases of Paul Thénard and petinine, discovered by Anderson, (Annual Report for 1847 and 1848, I, 497 and 502,) we have briefly alluded to the volatile organic bases belonging to the methyl- and ethyl-series, which have been discovered by Wurtz. A more detailed account of the origin and of the properties of these remarkable compounds, whose formation appears to throw much light upon the constitution of organic bases generally, has since been published in several notes presented to the French Academy(2). The bases

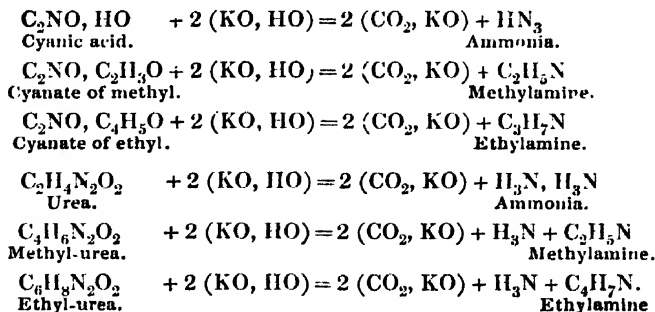
(1) Sill. Am. J. [2] VIII, 372; Chem. Gaz. 1850, 21.

(2) Upon ethylamine and methylamine, Compt. Rend. XXVIII, 223, 323; XXIX, 169; Instit. 1849, 100, 257; Laur. and Gerh. C. R. 1849, 120; J. Pr. Chem. XLVII, 345;

Homologues of ammonia.

hitherto described by Wurtz are methylamine,  $C_2H_7N$ , ethylamine,  $C_4H_9N$ , and amylamine,  $C_{10}H_{23}N$ . According to Gerhardt's suggestion, Anderson's petinine would be closely allied to these bases, when viewed as butylamine,  $C_8H_{17}N$ . According to their composition these substances may be regarded as the oxides of the ether-radicals, whose oxygen is replaced by amidogen, or as ammonia in which 1 equiv. of hydrogen is replaced by 1 equiv. of methyl  $C_2H_3$ , ethyl  $C_4H_5$ , amyl  $C_{10}H_{11}$ , &c., a mode of viewing the organic bases generally enunciated by Liebig as far back as 1840(1). In his report(2) on Wurtz's paper to the French Academy, Dumas points out the parallelism of these substances with the alcohols, the ethers, the aldehydes of the various acids and these acids themselves, the several terms of these various groups invariably differing by  $C_2H_2$ , or a multiple; he considers these bases as compounds of the carbohydrides  $C_2H_2$ ,  $C_4H_4$ , &c., with ammonia, or in general terms as  $n C_2H_2, NH_3$ . He extends this view to the other volatile bases, which he represents by the general formula  $C_m H_{m-h}, NH_3$  ( $m=12$ ,  $h=8$  for aniline;  $m=14$ ,  $h=8$  for toluidine). This view coincides in all essential points with Berzelius' theory.

The researches of Wurtz have shown that these bases are chiefly obtained in two reactions. They are formed by the action of potassa on the one hand upon the ethers of cyanic or cyanuric acids, and on the other upon the homologues of urea. These processes are analogous to the decompositions induced by potassa in hydrated cyanic acid and ordinary urea. In both cases carbonic acid is produced, remaining behind in combination of potassa.



Chem. Gaz. 1849, 115; upon amylamine, Compt. Rend. XXIX, 186; Instit. 1849, 258; J. Pharm. [3] XVI, 277; upon the three bases Ann. Ch. Pharm. LXXI, 330; J. Pr. Chem. XLVIII, 238.—Wurtz originally proposed the terms *methyl-* and *ethylamide*; amylamine he called *valeramine*; Dumas proposed the terms *methyliaque*, *ethyliaque*, *butyliaque*, and *amyliaque*; Gerhardt the names *methammine*, *ethammine*, &c.

(1) Handwörterb. d. Chem. von Liebig, Pogendorff and Wöhler, I, 698; comp. Ann. Ch. Pharm. LXXI, 346.

(2) Compt. Rend. XXIX, 203; J. Pharm. [3] XVI, 199; Ann. Ch. Pharm. LXXI, 342.

From Rochleder's researches on caffeine (page 263), we know that methylamine is formed moreover by the action of chlorine upon caffeine. The odour of these substances, which resembles that of ammonia in so high a degree, renders it probable that they have been frequently confounded with ammonia itself. Lastly, A. W. Hofmann has discovered that Wurtz's bases may be formed moreover in a perfectly different manner. We shall return to his researches presently (page 272).

Homologues of ammonia.

**Methylamine.**—This substance is prepared by gently heating the well-dried hydrochlorate of the base with its double weight of caustic lime, and collecting the gas over mercury. This gas, which at about  $0^{\circ}$  liquifies into a very mobile fluid of a strongly ammoniacal odour, is heavier than air; its sp. gr. was found to be 1.13 at  $25^{\circ}$  (theory 1.075). 1 vol. of water dissolves at  $12^{\circ}$  1040 vols., at  $25^{\circ}$  959 vols. of methylamine-gas; hence of all gases known it is dissolved by water in largest quantity. Charcoal absorbs it like ammonia; like the latter, it combines with its own vol. of hydrochloric acid, and with half its vol. of carbonic acid gas. Methylamine restores the blue colour of reddened litmus, and produces white clouds with hydrochloric acid vapours; it is inflammable and burns with a yellowish flame. Potassium heated in its vapour is converted into cyanide of potassium, hydrogen being liberated ( $C_2H_5N + K = KC_2N + 5 H$ ).—The aqueous solution of the base has the odour of the gas and a pungent caustic taste; with iodine it yields hydriodate of methylamine, and a red powder corresponding to iodide of nitrogen. With most of the metallic oxides methylamine exhibits the same deportment as ammonia; with salts of protoxide of copper it yields a bluish-white precipitate, which dissolves in an excess of the base, forming a deep-blue solution. The salts of cadmium, cobalt and nickel, are precipitated by methylamine; the precipitate does not, however, dissolve in an excess of the base. With nitrate of silver a precipitate is produced which redissolves in an excess of methylamine; the solution when allowed to evaporate spontaneously, deposits a black substance which does not explode, either by the action of heat or by percussion. Chloride of silver is easily soluble in a solution of methylamine.—Wurtz prepared the *hydrochlorate of methylamine* by boiling cyanurate of methyl with potassa, collecting the cooled gas in water, saturating with hydrochloric acid and evaporating. It crystallises in iridescent plates, assuming the lustre of mother-of-pearl after drying, and containing  $C_2H_5N$ ,  $HCl$ . The *platinum-salt*,  $C_2H_5N$ ,  $HCl$ ,  $PtCl_2$ , forms golden-yellow scales which are soluble in water. *Nitrate of methylamine* crystallises in transparent prisms which are soluble in water.

**Ethylamine** is prepared, like the preceding base, by heating its hydrochlorate with lime. The gas thus evolved is condensed in a refrigerated receiver. Ethylamine is a very mobile liquid which boils at  $18^{\circ}$ . It possesses a penetrating ammoniacal odour, restores

Ethyl-  
amine.

the blue colour of reddened litmus paper, and burns with a bluish flame; it is soluble in water in all proportions, and exhibits the same deportment with metallic oxides as methylamine. When mixed with oxalic ether it soon deposits crystals of ethyloxamide,  $C_6H_8NO_2$ . Ethylamine has the composition  $C_4H_7N$ . *Hydrochlorate of ethylamine*,  $C_4H_7N$ ,  $HCl$ , is readily soluble in absolute alcohol; it crystallises in plates which fuse at temperatures higher than  $100^\circ$ , and solidifies on cooling to a crystalline mass. The *platinum-salt*,  $C_4H_7N$ ,  $HCl$ ,  $PtCl_2$ , forms golden-yellow scales which are soluble in water.

**Amylamine.**—Wurtz found that cyanate of amyl, prepared by distilling cyanate of potassa with sulphamylate of potassa, is readily decomposed by boiling with potassa. The products of this reaction are carbonate of potassa and amylamine which distils over, chiefly dissolved in water. On saturating the liquid thus obtained with hydrochloric acid, white unctuous scales of hydrochlorate of amylamine,  $C_{10}H_{13}N$ ,  $HCl$ , are formed, which are soluble in water and in alcohol, and are not altered in the air. The platinum-salt,  $C_{10}H_{13}N$ ,  $HCl$ ,  $PtCl_2$ , crystallises from water in golden-yellow plates. The hydrochlorate, when distilled with lime, yields the amylamine in a state of purity. It is a liquid of a pungent, bitter taste, and ammoniacal odour. Its aqueous solution precipitates the salts of silver and copper, and the precipitates are soluble in an excess of the base. Hydrated protoxide of copper and chloride of silver are somewhat less soluble in amylamine than in ethylamine, methylamine, and ammonia.

**Farther Series of Homologous Bases.**—In an elaborate paper on the molecular constitution of the volatile organic bases, A. W. Hofmann(1) describes a method by means of which not only the bases described by Wurtz, but a great number of other homologous volatile alkaloids may be produced. He found that, by the action of the bromides and iodides of the alcohol-radicals (methyl, ethyl, and amyl) upon ammonia, upon aniline, nitraniline, &c., 1, 2, or 3 equivs. of hydrogen in the former may be replaced by 1, 2, or 3 equivs. either of one or several of these radicals. The number of homologue volatile bases already prepared by Hofmann, according to this method, is very great, and the series of similar alkaloids, the existence of which may be anticipated with certainty, is almost infinite. We here give a synopsis of the formulæ representing the terms of this interesting chain, as far as they have been investigated by Hofmann.

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(1) Phil. Trans. 1850, I, 93; Ann. Ch. Pharm. LXXIV, 117; Ann Ch. Phys. [3] XXX, 67; Chem. Soc. Qu. J. III, 279; J. Pharm. [3] XVIII, 161; Gerh. and Laur. C. R. 1850, 252; preliminary communication, Ann. Ch. Pharm. LXXII, 91; J. Pr. Chem. XLVIII, 243; Instit. 1849, 258; Compt. Rend. XXIX, 184; XXX, 146; J. Pharm. [3]; XVII, 67, 298; Chem. Gaz. 1850, 276.

Ammonia (as Type) $H, H, H, N$ :		
Amidogen-bases.	Imidogen-bases.	Nitrile-bases.
$H, H, C_{12}H_5, N$ Aniline (phenylamine).	$H, C_4H_5, C_{12}H_5, N$ Ethylaniline.	$C_4H_5, C_4H_5, C_{12}H_5, N$ Diethylaniline.
	$H, C_2H_5, C_{12}H_5, N$ Methylaniline.	$C_2H_5, C_4H_5, C_{12}H_5, N$ Methylethylaniline.
	$H, C_{10}H_{11}, C_{12}H_5, N$ Amylaniline.	$C_{10}H_{11}, C_{10}H_{11}, C_{12}H_5, N$ Diamylaniline.
		$C_4H_5, C_{10}H_{11}, C_{12}H_5, N$ Ethylamylaniline.
$H, H, C_{12}(H_4Cl), N$ Chloraniline.	$H, C_4H_5, C_{12}(H_4Cl), N$ Ethylchloraniline.	$C_4H_5, C_4H_5, C_{12}(H_4Cl), N$ Diethylchloraniline.
$H, H, C_{12}(H_4Br), N$ Bromaniline.	$H, C_4H_5, C_{12}(H_4Br), N$ Ethylbromaniline.	
$H, H, C_{12}(H_4NO_4), N$ Nitraniline.	$H, C_4H_5, C_{12}(H_4NO_4), N$ Ethylonitraniline.	
$H, H, C_4H_5, N$ Ethylamine.	$H, C_4H_5, C_4H_5, N$ Diethylamine.	$C_4H_5, C_4H_5, C_4H_5, N$ Triethylamine.

This synopsis exhibits a perspicuous survey of these substances, of their mutual connection, and of the molecular arrangement of their elements. We now pass on to a description of the preparation and of the most important properties of the several compounds.

**Ethylamine.**—Bromide of ethyl acts but very slowly upon ammonia in the cold; a mixture of the bromide with an alcoholic solution of ammonia deposits after 24 hours a copious precipitate of bromide of ammonium, the mother-liquor retaining hydrobromate of ethylamine, together with the free base. If concentrated ammonia-solution, mixed with an excess of bromide of ethyl, be sealed into a piece of combustion-tube of about 2 feet in length, and the mixture be immersed into boiling water, a lively ebullition ensues, and the transformation is rapidly accomplished. It may be considered as complete when the bromide of ethyl, after a quarter of an hour's ebullition, ceases to diminish in volume. The tube now contains hydrobromate of ethylamine, which, by distillation with lime, yields the base with all the properties described by Wurtz (see p. 272). Hofmann has established the composition of the ethylamine thus produced by the analysis of the platinum-salt. The reaction is represented by the equation,  $H_3N + C_4H_5Br = C_4H_7N, HBr$ .

**Diethylamine.**—Ethylamine, when treated in a similar manner with an excess of bromide of ethyl, yields after a few hours hydrobromate of diethylamine which is deposited in needles from the yellow solution. On distilling this salt with potassa the base itself passes over. It is a very volatile, inflammable, strongly alkaline liquid which is very readily soluble in water. The analysis of the platinum-salt, which crystallises in orange-red grains, led to the

Triethylamine.

formula  $C_8H_{11}N = C_4H_5, C_4H_5, H, N$ . Hence diethylamine is isomeric with butylamine (p. 270).

**Triethylamine.**—A concentrated solution of diethylamine, when mixed with bromide of ethyl, solidifies, after a short ebullition, into a mass of fibrous crystals, which are the hydrobromate of diethylamine. Distillations of this salt with potassa yields the triethylamine as a liquid which is still very volatile, inflammable, and soluble in water, but less so than the preceding base. The platinum-double-salt forms large, regular, magnificently orange-red rhombic crystals. The analysis of this salt led to the formula  $C_{12}H_{15}N = C_4H_5, C_4H_5, C_4H_5, N$  for triethylamine.—On treating this base again with bromide of ethyl, there are formed, together with hydrobromate of triethylamine, white, opaque, granular crystals, whose investigation we are promised.—Hofmann thinks that phosphoretted and arseniatted hydrogen may possibly comport themselves with the chlorine-, bromine- and iodine-compounds of the alcohol-radicals in a similar manner as ammonia; in this case the compound  $C_6H_9P$ , discovered by P. Thénard, (1) would correspond in the phosphoretted methyl-series to triethylamine.

**Ethylaniline.**—Aniline, when gently heated with an excess of bromide of ethyl, yields flat four-sided tables of hydrobromate of ethylaniline; if an excess of aniline be employed, the new base remains in the mother-liquor, hydrobromate of aniline being deposited in prismatic crystals.—Ethylaniline, in a state of purity, is obtained by decomposing the hydrobromate with concentrated potassa and rectifying the base separated, previously desiccated by potassa. It is a colourless liquid, powerfully refracting light, and rapidly turning brown on exposure to the atmosphere. Its odour is similar to that of aniline. It boils constantly at  $201^\circ$ , and has at  $18^\circ$  the sp. gr. 0.954. Ethylaniline does not exhibit the violet reaction with hypochlorites, which is characteristic of aniline, but its solution in acids imparts to fir-wood the yellow colour. In contact with dry chromic acid it is inflamed like aniline. The formula of ethylaniline is  $C_{12}H_9, C_4H_5, H, N$ . The salts of this base are very soluble in water, and crystallise better from alcohol than from water. *Hydrobromate of ethylaniline*,  $C_{16}H_{11}N, HBr$ , forms large, very regular tables, which are obtained by the spontaneous evaporation of the alcoholic solution. When gently heated, this salt sublimes without decomposition, but is split into bromide of ethyl and aniline, when exposed to a rapidly rising temperature.—The *platinum-salt*,  $C_{16}H_{11}N, HCl, PtCl_2$ , is more soluble in water than the corresponding aniline-compound. It crystallises in yellow needles, frequently of an inch in length.—Terchloride of gold and protochloride of mercury yield,

with ethylaniline, yellow, oily precipitates, which are readily decomposed. Bromine gives rise to the formation of two crystalline compounds, one of which is basic, the other being indifferent. On passing a current of cyanogen into an alcoholic solution of the base, short yellow prisms are deposited, probably of cyanethylaniline  $C_7H_{11}N$ . Chloride of cyanogen is readily absorbed by ethylaniline, the base becomes hot, and a resinous mixture is formed of a neutral oil and the hydrochlorate of an oily volatile base. Phosgene-gas gives rise to the formation of hydrochlorate of ethylaniline and of a liquid not yet farther examined.

**Diethylaniline.**—On gently heating a mixture of ethylaniline with a large excess of bromide of ethyl, large four-sided tables of hydrobromate of diethylaniline are deposited, the mother-liquor retaining only coloured bromide of ethyl. The base is separated from this salt in a similar manner as ethylaniline; it boils at  $213^{\circ}5$ , has a sp. gr. 0.939 at  $18^{\circ}$ , and is not altered when in contact with the atmosphere. With chloride of lime, and with fir-wood, it comports itself like ethylaniline. Analysis led to the formula  $C_{20}H_{15}N = C_{12}H_5, C_4H_5, C_4H_5, N$ . *Hydrobromate of diethylaniline*,  $C_{20}H_{15}N, HBr$ , when gently heated, sublimes without decomposition, like the corresponding ethylaniline-salt; when rapidly heated, it splits into bromide of ethyl and ethylaniline. The *platinum-salt*,  $C_{20}H_{14}N, HCl, PtCl_2$ , is less soluble, both in alcohol and water, than the corresponding salt of ethylaniline.—Diethylaniline, when again left in contact with bromide of ethyl for some time, does not appear to undergo any farther decomposition.

**Ethylchloraniline.**—A solution of chloraniline in bromide of ethyl, when heated for some days, deposits the hydrobromate of a yellow, oily base, which Hofmann considers as ethylchloraniline,  $C_{16}H_{10}ClN$ . If this substance be heated again to  $100^{\circ}$ , for 2 days, with an excess of bromide of ethyl, it assimilates a second equivalent of ethyl, and is converted into *dichlorethylaniline*,  $C_{20}H_{14}ClN$ , whose platinum-double-salt contains 25.3 per cent of platinum (found 24.5). Both these bases remain liquid even in the cold. They have the odour of anise-seed, and form very soluble salts. Bromaniline exhibits the same deportment with bromide of ethyl.

**Ethylonitraniline.**—Nitrانiline, when dissolved in bromide of ethyl, is converted, even at the common temperature, but more readily by ebullition, into hydrobromate of ethylonitraniline, which is deposited in large pale-yellow crystals. Addition of an alkali to this salt separates the base in form of a brown oil, which after some time solidifies into a crystalline mass. Ethylonitraniline is readily soluble in alcohol and ether, less so in boiling water, from which it crystallises in stellar groups of yellow needles. Its salts are as soluble as the corresponding compounds of nitraniline. The analysis



Methylaniline.

of the platinum-double-salt led to the formula  $C_{16}H_{10}N_2O_4$ ,  $HCl$ ,  $PtCl_2$  (theory 26.51, exp. 26.23 per cent of platinum).

**Methylaniline.**—A mixture of aniline and bromide of ethyl rapidly solidifies to a crystalline mass of hydrobromate of methylaniline. If iodide of methyl be substituted for the bromide, the mixture enters at once into ebullition. The base, separated from the hydrobromate or hydriodate, is a transparent oil, which boils at  $192^\circ$ , and imparts a blue colour to a solution of chloride of lime, though in a less decided manner than aniline; it has a peculiar odour differing from that of aniline. The analysis of the platinum-double-salt, which is readily decomposed, led to the formula  $C_{14}H_9N = C_{12}H_5, C_2H_3, H, N$ , for the base (exp. 31.55, theory 31.52 per cent of platinum).

**Methylethylaniline.**—A mixture of iodide of methyl and ethylaniline solidifies, after several days' exposure to  $100^\circ$ , to a crystalline compound. The base contained therein smells like the preceding one, but acts no longer upon chloride of lime. Its salts are so soluble, that they are scarcely capable of crystallising. Even the platinum-salt is a yellow oil. Hofmann considers this base as  $C_{18}H_{13}N = C_{12}H_5, C_4H_5, C_2H_3, N$ .

**Amylaniline.**—The action of bromide of amyl upon aniline gives rise to the formation of splendid crystals of hydrobromate of aniline, amylaniline remaining in solution. If the bromide of amyl be in excess, and the mixture be heated in the water-bath, the whole of the aniline is converted into hydrobromate of amylaniline. Separated from the hydrobromate by potassa, it is a colourless oil, possessing at the common temperature the odour of roses, but smelling strongly of fusel-oil, when heated. It boils constantly at  $258^\circ$  ( $3 \times 18^\circ$  higher than ethylaniline). Its salts, with hydrochloric, with hydrobromic, and with oxalic acid, are pretty insoluble, and unctuous to the touch; when heated with water, they collect as an oily layer on the surface of the liquid. The platinum-salt is yellow and unctuous. The composition of amylaniline is  $C_{22}H_{17}N = C_{12}H_5, C_{10}H_{11}, H, N$ .

**Diamylaniline** is obtained in the form of the hydrobromate, by exposing a mixture of amylaniline with bromide of amyl, for several days, to a temperature of  $100^\circ$ . The base is separated like the preceding ones; it boils between  $275^\circ$  and  $280^\circ$ . Its salts are soluble with difficulty. The composition of the base, determined by the analysis of the platinum-double-salt, is  $C_{32}H_{27}N = C_{12}H_5, C_{10}H_{11}, C_{10}H_{11}, N$ .

**Amylethylaniline** is formed by the action of bromide of ethyl upon amylaniline, at the temperature of the water-bath. It is a colourless oil, boiling at  $262^\circ$ . The hydrochlorate and the hydrobromate crystallise with facility; the platinum-salt is an orange-

yellow crystalline mass, by whose analysis the formula  $C_{26}H_{21}N = C_{12}H_5, C_{10}H_{11}, C_4H_5, N$ , of ethylamylaniline was established. The same body, with exactly the same properties, is obtained by the action of bromide of amyl upon ethylaniline. Hydrobromate of ethylamylaniline, when heated, splits into bromide of amyl and ethylaniline.

Amyl-  
ethylaniline.

In concluding his paper, Hofmann directs attention to the great number of isomerisms which are pointed out by these researches. Toluidine is isomeric with methylaniline ( $C_{14}H_9N$ ); the two bases differ however essentially in their properties. In a similar manner, cumidine is isomeric with methylethylaniline ( $C_{18}H_{13}N$ ), &c.; ethylamine with dimethylamine ( $C_4H_7N$ ); butylamine with diethylamine ( $C_8H_{11}N$ ), &c.

**Nitromesidine.**—Maule(1) has obtained a new organic base, which he calls *nitromesidine*, by decomposing an alcoholic solution of dinitromesitilole,  $C_{18}H_{10}(NO_4)_2$ , (isomeric with dinitrocumole) by means of hydrosulphuric acid. It has the same composition as nitrocumidine, viz.  $C_{18}H_{12}N_2O_4 = C_{18}H_{12}(NO_4)N$ . Nitromesidine forms long golden-yellow needles, fusing below  $100^\circ$ , and volatile, without decomposition, at the temperature of boiling water; they are readily soluble in alcohol and ether, forming neutral solutions of a disagreeable, bitter taste. The salts of nitromesidine are soluble in alcohol; their reaction is acid; most of them are decomposed by water. *Hydrochlorate of nitromesidine*,  $C_{18}H_{12}N_2O_4, HCl$  (at  $100^\circ$ ), crystallises in colourless needles. The *platinum-salt*,  $C_{18}H_{12}N_2O_4, HCl, PtCl_2$ , is obtained by mixing saturated solutions of bichloride of platinum and hydrochlorate of nitromesidine; it forms groups of yellow crystals. The sulphate crystallises in white satiny needles, which are readily decomposed by water. *Phosphate of nitromesidine*,  $3 C_{18}H_{12}N_2O_4, 3 HO, PO_5$  (at  $100^\circ$ ) crystallises in orange-yellow plates.—The action of bromine upon nitromesidine is very violent, and gives rise to a dark, oily substance; while nitrocumidine by this treatment is converted into a solid crystalline body. The alcoholic solution of this base, when exposed to the action of chlorine, yields a white mass, soluble in hot ether.—Trinitromesitilole,  $C_{18}H_9(NO_4)_3$ , is but slowly attacked by hydrosulphuric acid; it likewise gives rise to the formation of a basic body.

**Alcohols and Collateral Matters.**—**Iodide of Methyl.**—With regard to the decomposition of iodide of methyl by zinc, see iodide of ethyl.

**Salicylate of Oxide of Methyl. Anisole.**—By distilling salicylate of oxide of methyl, or anisic acid ( $C_{16}H_8H_6$ ), which is isomeric with this sub-

Salicylate  
of oxide of  
methyl.  
Anisole.

stance, with an excess of baryta, Cahours some time since (1) prepared a compound which he termed anisole. He has now published some new investigations on this substance (2).—Anisole, from whichever of these two compounds it is prepared, is a colourless liquid of an agreeable aromatic odour, boiling at  $152^{\circ}$ , and of sp. gr. 0.991, at  $15^{\circ}$ .—It forms with an equal weight of concentrated sulphuric acid, a mixture which is perfectly soluble in water; on saturating the acid liquid with carbonate of baryta a compound is obtained which is deposited in white, lustrous plates when the filtrate is evaporated. On treating anisole with fuming sulphuric acid, an excess being avoided, the same acid is produced; but when the acid mixture is treated with water, crystalline flocks are deposited, which crystallise from the alcoholic solution in the form of delicate needles.—Anisole forms with chlorine and bromine crystallisable products of substitution.—If fuming nitric acid is added in small quantities at a time to anisole which is kept cool by being surrounded by ice, a blackish-blue oily liquid is formed, which is purified by washing with water containing a small quantity of potassa in solution, dried by fused chloride of calcium, and then carefully distilled. In this process unchanged anisole first passes over and then *nitranisole*,  $C_{14}H_7(NO_4)O_2$ , which is an amber-coloured liquid, heavier than water, and is not attacked by aqueous solution of potassa even when heated; it is dissolved by moderately-warmed sulphuric acid, and is again precipitated unchanged by addition of water. When heated with fuming nitric acid it is converted into dinitranisole and trinitranisole. *Dinitranisole*,  $C_{14}H_6(NO_4)_2O_2$ , is immediately formed on treating anisole with fuming nitric acid and allowing the mixture to boil for some minutes; it had previously been obtained by Cahours (3) on treating anisole acid with fuming nitric acid (comp. p. 280). *Trinitranisole*,  $C_{14}H_5(NO_4)_3O_2$ , is also formed by the treatment of anisole with a mixture of equal parts of fuming nitric and sulphuric acids, and had likewise been prepared by Cahours at an earlier period by the action of the mixture of acids on anisole acid (4).

By the treatment of nitranisole with an alcoholic solution of sulphide of ammonium sulphur is deposited, and a base is formed, which has received the name of *anisidine*. The alcoholic solution is

(1) Ann. Ch. Phys. [3] X, 327.

(2) Ann. Ch. Phys. [3] XXVII, 439; J. Pr. Chem. XLIX, 262; Compt. Rend. XXVIII, 381 (in abstr.); Instit. 1849, 89; J. Pr. Chem. XLVII, 423; Phil. Mag. [3] XXXIV, 476. In this abstract Cahours, moreover, incidentally states that the second product of the action of fuming nitric acid upon toluole, the crystalline dinitrotoluole produces a base when treated with an alcoholic solution of sulphide of ammonium. In the same manner as nitrotoluole yields toluidine, the latter is converted into *nitrotoluidine*  $C_{14}H_8(NO_4)N$ .

(3) Annual Report for 1847 and 1848, I, 412.

(4) Annual Report for 1847 and 1848, I, 412.

evaporated at a gentle heat to  $\frac{1}{2}$  or  $\frac{1}{4}$  of its original volume, and to the brown liquid hydrochloric acid is added in slight excess. Some water is then added, the sulphur separated by filtration, and the brownish-yellow filtrate evaporated at a gentle heat to crystallisation. The needles of hydrochlorate of anisidine which have crystallised out of the solution are dried between bibulous paper and distilled with concentrated solution of potassa, when the anisidine passes over as an oil with the aqueous vapour and solidifies on cooling. The composition of anisidine is  $C_{14}H_9NO_2$ , and it is distinguished from toluidine merely by containing 2 equivs. of oxygen. It yields crystallisable salts with hydrochloric, nitric, sulphuric, and oxalic acids; and its hydrochloric solution gives with bichloride of platinum a double salt which crystallises in yellow needles.—An alcoholic solution of *dinitranisole* is rapidly acted upon by sulphide of ammonium. The solution, filtered from the separated sulphur, is evaporated to  $\frac{1}{3}$  of its volume, and then heated to ebullition with a slight excess of dilute hydrochloric acid. Addition of ammonia then throws down a reddish crystalline precipitate which is washed with water and recrystallised from boiling alcohol. *Nitranisidine*,  $C_{14}H_8(NO_4)NO_2$ , is thus obtained in garnet-red, lustrous needles; it is insoluble in cold, but pretty soluble in hot water, and dissolves with facility in ether. It forms crystallisable salts with nitric, sulphuric, and hydrochloric acids; it fuses at a gentle heat, and when gradually heated more strongly yellow vapours are evolved which solidify in delicate yellow needles. Fuming nitric acid converts it into a viscid mass no longer possessed of basic properties: a similar effect is produced by bromine. Hydrochlorate of nitranisidine,  $C_{14}H_8(NO_4)NO_2, HCl$ , crystallises, from the solution of the base in hydrochloric acid, in brownish needles which may be obtained nearly colourless by pressure between bibulous paper and repeated recrystallisation. It is slightly soluble in cold, and dissolves readily in boiling water. From a mixture of the hot solutions of this salt and of bichloride of platinum the double salt  $C_{14}H_8(NO_4)NO_2, HCl + PtCl_2$  is deposited on cooling in brownish-orange-coloured needles. The hydrobromate corresponds in its composition to the hydrochlorate, and likewise crystallises in needles; the sulphate,  $C_{14}H_8(NO_4)NO_2, H_2O, SO_3$ , and the nitrate, which is of a corresponding composition, also crystallise in needles and are both obtained by dissolving the base in the dilute and slightly warmed acids. If crystals of nitranisidine are brought into contact with chloride of benzoyl no action takes place in the cold, but on gradually raising the temperature hydrochloric acid is formed together with *nitrobenzanisidide*,  $C_{28}H_{12}(NO_4)NO_4$ , a compound which is analogous to benzamide or benzanilide. By extracting the product successively with pure water, hydrochloric acid, and alkaline water, and recrystallising the residue from boiling alcohol, this compound is obtained in small, felted, yellowish needles which are not in

Salicylate  
of oxide of  
methyl.  
Anisole.

Salicylate  
of oxide of  
methyl.  
Anisole.

the least degree soluble in water, and only slightly soluble in ether. When gently heated the crystals fuse and volatilise, and are dissolved by sulphuric acid, at a moderate temperature, with a reddish-brown colour. In a similar manner chloride of cinnamyl yields *nitro-cinnanisidide*,  $C_{32}H_{14}(NO_4)NO_4$ , in small yellowish needles; chloride of cumyl and chloride of anisyl likewise yield analogous compounds. — *Trinitranisole*, when heated with an alcoholic solution of sulphide of ammonium, yields a blood-red liquid which speedily becomes dark-brown and finally solidifies; the liquid is heated to ebullition, evaporated to about  $\frac{1}{3}$ , and treated with hydrochloric acid in excess; when boiled and filtered the brownish filtrate yields on addition of ammonia, dark-red flocks which after being washed and dried form a non-crystalline red powder. This compound is *dinitranisidine*,  $C_{14}H_7(NO_4)_2NO_2$ , which is scarcely at all soluble in cold and only slightly soluble in boiling water. It is little soluble in cold alcohol, pretty soluble in hot alcohol, and only slightly in hot ether; from the two latter solutions it crystallises in violet-coloured needles. With hydrochloric, nitric and sulphuric acids, if not employed in excess, it forms soluble and crystallisable salts which are decomposed by water with separation of the base. By fuming nitric acid it is violently attacked at the boiling temperature, and converted into a brownish-yellow resinous mass which dissolves with a brown colour in potassa.

By the action of fuming nitric acid upon anisic acid, or upon nitranisic acid, there is formed, in addition to dinitranisole or trinitranisole, moreover, a new crystallisable acid which has received the name of *chrysanisic acid*. In order to obtain this acid in large quantity dry nitranisic acid is gently boiled for from half to three-quarters of an hour, with from  $2\frac{1}{2}$  to 3 times its weight of fuming nitric acid, and the liquid poured into from 15 to 20 times its volume of water. A mixture of chrysanisic acid with dinitranisole or trinitranisole separates as a yellow oil which soon solidifies. The solid mass is now pulverised, the chrysanisic acid extracted by dilute ammonia, and the extract evaporated to crystallisation. The ammonia-salt which crystallises out of the solution is dissolved in water and decomposed by dilute nitric acid; the precipitated yellow flocks of chrysanisic acid, after being washed with water, are dried on a porous tile and between bibulous paper, and recrystallised from boiling alcohol. Chrysanisic acid is thus obtained in small, lustrous, golden-yellow, rhombic plates of the formula  $C_{14}H_5N_3O_{14}$ , being isomeric with trinitranisole. It does not dissolve to any perceptible extent in cold, and only slightly in boiling water; it scarcely dissolves in cold alcohol, but abundantly in boiling alcohol, and also in ether. This compound fuses at a moderate heat, and evolves yellow vapours which condense to shining plates. When boiled with concentrated nitric acid it is converted into picric acid, and when distilled with

chloride of lime a large quantity of chloropicrin is produced. If accurately neutralised by potassa it forms a readily soluble salt which is decomposed into a brown mass on addition of a larger quantity of potassa. From the solution of this acid in dilute ammonia, the ammonia-salt crystallises in small brown needles,  $\text{NH}_4\text{O}, \text{C}_{14}\text{H}_4\text{N}_3\text{O}_{13}$ . The solution of this salt forms various precipitates with the salts of the metallic oxides; for example, with the salts of the protoxide of copper the precipitate is gelatinous and greenish-yellow, with salts of sesquioxide of iron it is bright-yellow, with zinc-salts likewise bright-yellow, with protochloride of mercury, if concentrated solutions be employed, it is reddish-yellow. The solution forms with acetate of lead a chrome-yellow, flocky precipitate, and with nitrate of silver it produces yellow flocks of the composition  $\text{AgO}, \text{C}_{14}\text{H}_4\text{N}_3\text{O}_{13}$ . By passing hydrochloric acid gas into an alcoholic solution of the acid, boiling the liquid, adding water, washing the precipitate thus formed first with ammoniacal and then with pure water, and finally recrystallising from boiling alcohol, the chrysanisate of oxide of ethyl,  $\text{C}_4\text{H}_5\text{O}, \text{C}_{14}\text{H}_4\text{N}_3\text{O}_{13}$ , is obtained in shining golden-yellow plates.

If the vapour of anhydrous sulphuric acid is passed into anisole, placed in a frigorific mixture, the liquid assumes a thicker consistence. On addition of water the undecomposed anisole floats upon the surface, sulphanisolic acid remains in solution, whilst *sulphanisolid*,  $\text{C}_{14}\text{H}_7\text{SO}_4$ , separates in delicate needles. When recrystallised from boiling alcohol it forms needles of a silvery lustre. When gently heated these needles fuse, and if more strongly heated, sublime; in concentrated sulphuric acid they dissolve with formation of sulphanisolic acid.

**Chloroform.**—Soubeiran and Mialhe(1) have published investigations regarding the difference between the chloroform prepared from wood-spirit and that obtained from spirit of wine(2). The former possesses an empyreumatic odour and induces nausea; it is specifically lighter (1.413) than the latter (1.496 at  $12^\circ$ ), and causes indisposition when inhaled.—According to these chemists, chloroform prepared from wood-spirit is contaminated with an empyreumatic, chlorinated oil which burns with a smoky flame and of which about 30 grms. could be separated from 500 grms. of chloroform. This oil is lighter than water, and commences to boil at  $85^\circ$ , but the boiling-point rises to  $133^\circ$ . By mere rectification this oil cannot be completely separated; but by rectification with concentrated sulphuric acid the greater part is destroyed.—In preparing chloroform from spirit of

Salicylate  
of oxide of  
methyl.  
Anisole.

(1) J. Pharm. [3] XVI, 5; Ann. Ch. Pharm. LXXI, 225; J. Pr. Chem. XLVIII, 86.

(2) Carl has published investigations on the preparation of chloroform from spirits of wine (Jahrb. Pr. Pharm. XVIII, 113); Dorvault upon testing it (J. Chim. Méd. [3] V, 41); a collection of recipes for preparing chloroform is given in the Ann. Ch. Pharm. LXXII, 94.

Chloro-  
form.

wine a similar oil is likewise formed, but in smaller quantity; 20 kilogrammes of chloroform gave, on rectification in a water-bath, only 40 grms. of this oil as residue; this oil is heavier than water, smells differently from that which is formed in the preparation of chloroform from wood-spirit, and possesses a different boiling-point, varying between  $68^{\circ}$  and  $117^{\circ}$ .—They moreover remark that chloroform when poured upon a double filter is solidified by the cold produced by its own evaporation; the chloroform which evaporates at the edges of the filter leaves the remaining portion frozen in white tufts.

**Alcohol.**—Despretz(1) has observed that absolute alcohol which was surrounded by liquid protoxide of nitrogen, the latter being placed moreover in a mixture of solid carbonic acid and ether, became thick under the bell of an air-pump, and on one occasion it even appeared to be solidified on the surface.

Bussy(2) has described the arrangement proposed by Conaty(3) for determining by the boiling-point the proportion of alcohol contained in a mixture; he has likewise described Silbermann's(4) apparatus for determining the amount of alcohol by expansion. He states that by the former the proportion of alcohol, even to 1 per cent, may be accurately found. An apparatus for determining, by means of expansion, the proportion of alcohol contained in a mixture has also been described by Makins(5). For details we refer to the original memoirs.

**Alcoholates.**—Chodnew(6) has published investigations upon the alcoholates whose existence has been doubted by Einbrodt(7).—By dissolving dehydrated nitrate of magnesia in alcohol of 0.795 at  $20^{\circ}$ , boiling the solution, filtering whilst boiling hot, and allowing the filtrate to cool in a well-closed vessel, Chodnew obtained a white mass resembling margarin, which was fusible by heat; when pressed as much as possible between filtering paper it showed the composition  $\text{MgO}, \text{NO}_5 + 3 \text{C}_4\text{H}_6\text{O}_2$ . When a solution of anhydrous nitrate of magnesia in alcohol was evaporated in the air, moisture was invariably attracted, and a salt finally crystallised with 6 equivs. of water.—From a saturated solution of chloride of calcium in hot alcohol of 0.795 sp. gr. at  $20^{\circ}$ , containing about 1 per cent of water, no crystals were deposited on cooling; the liquid evaporated to a syrupy consistence gave on cooling a solid white mass which, after being pressed between bibulous paper, was soft and deliquescent, and contained 60.6 per cent of chloride of calcium. A solution of chloride of

(1) Loc. cit. p. 256.

(2) J. Pharm. [3] XV, 89.

(3) Annual Report for 1847 and 1848, II, 13.

(4) Annual Report for 1847 and 1848, II, 14.

(5) Chem. Soc. Qu. J. II, 224.

(6) Petersb. Acad. Bull. VIII, 137; Ann. Ch. Pharm. LXXI, 241; J. Pr. Chem. XLIX, 107.

(7) Comp. Annual Report for 1847 and 1848, II, 14.

calcium in alcohol of 0.795 sp. gr. at 20° by standing for some days *in vacuo* over sulphuric acid became thick and viscid, but no crystals were deposited; on cooling a portion in ice a crystalline tallowy mass was obtained, and after being thoroughly pressed exhibited the composition  $3 \text{CaCl} + 2 \text{C}_4\text{H}_6\text{O}_2 + 2 \text{HO}$ ; the other portion, by continued exposure *in vacuo*, became after 12 days dry and solid, and then contained 60.5 per cent of chloride of calcium, whilst the former contained 60.4 per cent. By dissolving chloride of calcium in warm alcohol of 0.790 sp. gr. at 23°, quickly filtering the solution and cooling the filtrate in ice, a crystalline white substance was obtained, which, after being well pressed, exhibited the composition  $\text{CaCl} + 2 \text{C}_4\text{H}_6\text{O}_2$ .

**Ether.**—Soubeiran(1) has described an apparatus for preparing ether on the large scale, in which rectified ether is at once obtained. In this, as in the more recent apparatus for distilling brandy, the first condensers are maintained sufficiently warm to evaporate the pure ether. He recommends the temperature of the ether mixture to be kept constantly at 130°, since at 140° a gaseous carbohydrogen is continually formed.

Mohr(2) has written against the ethyl-theory, and has endeavoured to give a better explanation of the formation of ether. He states, that 1 equiv. of spirit of wine, and 2 equivs. of sulphuric acid, give 1 equiv. of water, and a compound  $\text{C}_4\text{H}_5\text{O}_2$ , which he terms *aldide*, and  $\text{S}_2\text{O}_5$ ; the compound  $\text{C}_4\text{H}_5\text{S}_2\text{O}_7$  is decomposed, when more strongly heated in the hottest parts of the vessel, into ether,  $\text{C}_4\text{H}_5\text{O}$ , and sulphuric acid,  $2 \text{SO}_3$ ; the latter again forming, with spirit of wine in the cooler parts of the mixture, aldide-hyposulphuric acid,  $\text{C}_4\text{H}_5\text{S}_2\text{O}_7$ . In the formation of ethers of oxygenated acids, the spirit of wine loses 1 equiv. of hydrogen, and the hypothetical anhydrous acid 1 equiv. of oxygen; 1 equiv. of water being formed, the residuary elements uniting to produce ether. In the formation of ether, by means of hydrogen-acids, 1 equiv. of hydrogen in the alcohol unites with 1 equiv. of oxygen to form water, and 1 equiv. of the oxygen of the spirit of wine unites with 1 equiv. of the hydrogen contained in the acid; 2 equivs. of water being formed together with the ether. Mohr adopts the view first enunciated, but in his opinion not farther elaborated by Poggendorff(3), that the compound ethers are to be considered as amides. He views oxamide, acetic ether, and analogous bodies, sulphammon, urea, and gun-cotton, as amidogen-compounds.

**Iodide of Ethyl; Decomposition by Metals.**—Frankland(4) has published investigations regarding the isolation of the organic radi-

(1) J. Pharm. [3] XVI, 321.

(2) Arch. Pharm. [2] LVIII, 150, 259.

(3) Pogg. Ann. XXXVII, 75.

(4) Ueber die Isolirung der Aethyls, inaugural dissertation, Marburg, 1849; Ann. Ch.



Iodide of  
ethyl;  
decompo-  
sition by  
metals.

cals. In the first place, he has studied the decomposition of iodide of ethyl by metals, under the influence of pressure and elevated temperatures. The iodide of ethyl employed for the purpose was obtained by treating 7 parts of phosphorus with 35 of absolute alcohol, in a vessel surrounded by iced water, and gradually adding 23 parts of iodine. The liquid poured from the residue was distilled in a water-bath, the distillate being washed and mixed with iodine, until it remained slightly coloured; it was then dried over chloride of calcium, and repeatedly rectified over a mixture of chloride of calcium, mercury, and protoxide of lead. When boiled under a barometric pressure of  $746^{\text{mm}}\cdot 5$ , the thermometer, with its bulb in the vapour, indicated a temperature of  $71^{\circ}\cdot 6$ , and of  $72^{\circ}\cdot 2$ , with the bulb in the liquid; at  $16^{\circ}$  the sp. gr. was  $1\cdot 9164$ . The action of metals upon iodide of ethyl, or upon a mixture thereof with other liquids, was studied in the following manner. Frankland introduced the metal, in a finely-divided state, in a strong glass tube, closed by fusion at the lower extremity; the upper end of the tube was drawn out to a fine aperture, bent at right angles, and turned backwards. The liquid was introduced by alternately heating and cooling the tube, and after exhausting it of air, the drawn-out end was hermetically sealed, and the tube then heated in an oil-bath.

The decomposition of pure iodide of ethyl commences at about  $150^{\circ}$ ; on the zinc and the glass white crystals are deposited, whilst a colourless, readily mobile liquid remains, and occupies about half the volume of the iodide of ethyl employed. After heating to  $150^{\circ}$  for about two hours, the decomposition appeared to be completed; when the point of the tube was broken under water, about 40 times its volume of an ether-like-smelling gas (*A*) rushed out, whilst gradually the above-mentioned readily mobile liquid disappeared; the gas burned with a bright flame, and was perfectly absorbed by freshly-boiled alcohol. The crystalline mass remaining in the tube, dissolved in water with powerful effervescence, and the evolution of an analogous gas (*B*). The solution contained iodide of zinc, and no organic substance, except a trace of undecomposed iodide of ethyl. The gas *A* was collected over a dilute solution of sulphide of potassium, in order that it might be kept sufficiently long for the complete absorption of the vapour of undecomposed iodide of ethyl, without becoming mixed with atmospheric air, more particularly oxygen, by diffusion, which would have rendered the eudiometrical determination uncertain. The sp. gr. of the gas, when thus purified and dried by caustic potassa, was  $1\cdot 525$ ; by careful endiometrical investigations, it was found that 100 volumes consisted of

50.03 ethyl ( $C_4H_5$ ), 25.79 methyl ( $C_2H_3$ ), 21.70 clayl ( $C_2H_2$ ), and 2.48 nitrogen. Assuming that the sp. gr. of the gases  $C_4H_5$  and  $C_2H_3$  correspond, like  $C_2H_2$ , to a condensation to 2 volumes of the equivalents, as expressed by these formulæ, the calculated sp. gr. of such a gaseous mixture is = 1.504.—The gas *B* evolved from the crystalline residue, which had been kept for about 12 hours, and which only amounted to about  $\frac{1}{10}$ th of the volume of the gas *A*, was investigated in the same manner. If the proportion of nitrogen is not taken into consideration, 100 volumes contained 2.8 elayl, from 72.0 to 74.8 ethyl, and from 22.4 to 25.3 methyl. On the other hand, the crystalline residue, which was decomposed by water immediately after the evolution of the gas *A* had ceased, yielded a gas which contained, after the separation of elayl and iodide of ethyl vapour by fuming sulphuric acid, and of the sulphurous acid by potassa, 47.9 volumes of ethyl and 52.1 methyl.—Frankland considers it probable that the methyl in the crystalline residue is present in chemical combination, and the ethyl merely as a mechanically mixed liquid. He states, that the decomposition of iodide of ethyl by zinc proceeds, first of all, in such a manner, that  $C_4H_5I$  and Zn are transformed into  $ZnI + C_4H_5$  (ethyl), a portion of the liberated ethyl being decomposed into elayl and methyl ( $C_4H_5 = C_2H_2 + C_2H_3$ ), and that a portion of the latter probably unites with the iodide of zinc, in definite proportion, to produce the crystalline compound.—Since methyl and elayl probably boil at lower temperatures than that at which ethyl boils, Frankland conjectured that, on opening a decomposition-tube, the two former gases would escape first, and that the gas evolved from the last portion of the liquid would be pure ethyl. Experiment has confirmed this supposition; the gas, which after the opening of the tube was collected only when the evolution proceeded in a slow and regular stream, exhibited the composition  $C_4H_5$  after it had been freed from elayl and the vapours of iodide of ethyl by fuming sulphuric acid, and from sulphurous acid by potassa; according to a diffusion-experiment it exhibited exactly the deportment which a pure gas of 2.0 sp. gr. should show according to the law of Graham(1). This gas, which Frankland terms ethyl and considers to be represented by the formula  $C_4H_5$ , which corresponds to a condensation to 2 volumes, is colourless, and possesses a slightly ethereal odour; in the pure state, however, it is probably odourless. It burns with a highly luminous white flame, and is not condensed even at  $18^\circ$ , when it is passed with the accompanying methyl through a glass tube maintained at this temperature; in one of Oerstedt's condensing

Iodide of  
ethyl;  
decompo-  
sition by  
metals.

(1) Frankland recommends the observation of diffusion to distinguish whether the composition of a gas mixing with the air remains constant, and whether the gas is to be viewed as a pure compound. He likewise advises this method for determining the sp. gr. of smaller quantities of gas.

Iodide of  
ethyl;  
decompo-  
sition by  
metals.

apparatus, however, it is converted, under a pressure of  $2\frac{1}{2}$  atmospheres at  $+3^{\circ}$ , into a transparent mobile liquid; so that at the ordinary pressure of the atmosphere its boiling-point may lie at about  $-23^{\circ}$ . It is insoluble in water; one volume of absolute alcohol absorbs at  $14^{\circ}2$ , and under a pressure of  $744^{\text{mm}}\cdot 8$ ,  $18\cdot 13$  volumes, which are again evolved on adding a small quantity of water; by fuming sulphuric and concentrated nitric acid or chromic acid it is not attacked; nor does it combine either with iodine or sulphur even when heated; but in contact with sulphur, at a red-heat, hydrosulphuric acid is formed and carbon separated. When mixed with half its volume of oxygen and passed over spongy platinum it remains at the ordinary temperature unchanged; if, on the other hand, it is gently warmed, the spongy platinum becomes red-hot, whilst water, and probably also marsh-gas, are formed with deposition of a small quantity of carbon. Pentachloride of antimony does not absorb it even in direct sun-light; it is not acted upon by chlorine in the dark; a dry mixture, however, of equal volumes of the two gases forms in diffused light a colourless liquid with change of volume. Bromine acts upon ethyl when both are exposed to solar irradiation and gently warmed. The products of decomposition will be accurately investigated by Frankland at a future period.

If equal parts of water and iodide of ethyl with zinc are heated as above-mentioned in a closed glass tube, exhausted of air, decomposition takes place at a temperature even lower than that which is required for iodide of ethyl and zinc alone. After two hours the action appeared to have ceased; the liquid contents of the tube were thick, and solidified on cooling to a white amorphous mass. On opening the tube under water containing some sulphide of potassium, a large quantity of gas escaped; the white residue remaining in the tube, smelling strongly of ether, contained however no organic body in chemical combination, but consisted of basic iodide of zinc, and evolved no gas when treated with water. The gas which escaped on opening the tube, and termed by Frankland *methyl*, has the composition  $\text{C}_2\text{H}_3$ ; it is a colourless gas, almost insoluble in water, but soluble in alcohol, which absorbs  $1\cdot 22$  times its volume at  $8^{\circ}8$ , and under a pressure of  $665^{\text{mm}}\cdot 5$ . It possesses at first a feebly ethereal odour, which, after treatment with alcohol and sulphuric acid, completely disappeared. It is not liquified even at  $-18^{\circ}$ , nor at  $+3^{\circ}$ , under a pressure of 20 atmospheres. Chlorine does not act upon it in the dark, but when the mixture is exposed to diffused daylight the colour of the chlorine quickly disappears. This gas is identical with that which is obtained in the decomposition of cyanide of ethyl by potassium(1), and by the elec-

(1) Annual Report for 1847 and 1848, II, 16.

tolysis of acetic acid(1). Its formation is explained by the equation  $C_4H_5I + H_2O + 2 Zn = 2 C_2H_3 + ZnI_2, ZnO$ : Frankland recommends this method for preparing methyl-gas, but advises that not more than 3·5 grms. of the iodide should be introduced into one decomposition tube, in order to prevent the temperature from rising above  $180^\circ$ , and that the tubes should be heated within a wooden chamber, which is furnished with a glass window, for the purpose of observing the course of the operation.

If zinc is heated with iodide of ethyl and absolute alcohol, in a similar manner, the result is exactly the same, methyl-gas, ether, and basic iodide of zinc being formed ( $C_4H_5I + C_4H_5O_2 + 2 Zn = 2 C_2H_3 + C_4H_5O + ZnI_2, ZnO$ ).—Equal volumes of iodide of ethyl and ether when maintained with zinc, in a similar manner, at about  $150^\circ$ , until the decomposition appeared to have been completed, yielded on cooling a thick oily liquid. On opening the tube only a few cubic centimeters of gas escaped, but a much more powerful evolution of gas took place by treating the residue with water; in 100 volumes the gas contained, independently of an accidental admixture of nitrogen, 27·7 ethyl, 68·2 methyl, 4·1 ethyl.

Iron, lead and copper, when heated in the above-mentioned manner with iodide of ethyl to from  $150^\circ$  to  $200^\circ$ , decompose scarcely a trace of the iodide. At about  $160^\circ$  arsenic forms, with iodide of ethyl, a blood-red liquid, which on cooling solidifies in magnificent crystals consisting probably of  $AsI_3$ . On opening the tube it was found to be a vacuum, and the crystalline mass, when treated with water, yielded no gas. Tin effects the decomposition of iodide of ethyl at about the same temperature as arsenic, the liquid iodide being slowly converted thereby into a yellow, oily liquid, which on cooling became crystalline; no evolution of gas was observed on opening the tube, nor on treating the residue with water. Potassium decomposes iodide of ethyl at about  $130^\circ$  with facility, and forms products of decomposition which correspond with those obtained by means of zinc; the gases, however, which are formed invariably contain a portion of hydrogen, derived from the hydrate of potassa with which the potassium employed was coated.

In a notice regarding organic bodies which contain metals, phosphorus, &c., Frankland(2) has farther stated that by acting with zinc upon iodide of methyl in the manner above-mentioned, methyl-gas is evolved, whilst in the decomposition-tube a white crystalline residue remains, which is decomposed on adding water with ignition and evolution of pure marsh-gas. When this residue is distilled in an apparatus filled with dry hydrogen-gas, it yields a colourless,

Iodide of ethyl; decomposition by metals.

(1) Comp. p. 228 of this Report.

(2) Ann. Ch. Pharm. LXXI, 213; Chem. Soc. Qu. J. II, 297; Ann. Ch. Phys. [3] XXIX, 253; J. Pharm. [3] XVII, 153.

Iodide of  
ethyl;  
decompo-  
sition by  
metals.

penetrating, and disagreeably smelling liquid, which burns in contact with the air or oxygen with a brilliant greenish-blue flame, and formation of dense clouds of oxide of zinc. The vapour of this compound, mixed with a large quantity of methyl and marsh-gas, does not spontaneously inflame; when heated, however, it burns with the characteristic flame, and if a cold surface is held therein a metallic layer of zinc is deposited, and is surrounded by a ring of oxide. The vapours of this liquid appear to be highly poisonous; they decompose water with the same power as potassium, with formation of 1 equiv. of oxide of zinc to 2 equivs. of marsh-gas, proving the composition of the liquid to be  $C_2H_3Zn$ , as confirmed by direct analysis ( $C_2H_3Zn + HO = ZnO + 2CH_2$ ). Frankland proposes for this compound the term *zinc-methyl*, and considers it probable that it is capable of combining directly with oxygen, chlorine, &c., and deporting itself as a radical.—A corresponding ethyl-compound is formed in the decomposition of iodide of ethyl by zinc; *zinc-ethyl*,  $C_4H_5Zn$ , which is formed, is less volatile than zinc-methyl, and yields by decomposition with water methyl-gas in addition to oxide of zinc ( $C_4H_5Zn + HO = ZnO + 2C_2H_3$ ). From the existence of zinc-ethyl Frankland explains the above-mentioned action of water upon the residue obtained by the action of zinc upon iodide of ethyl, and also the decomposition of the two latter bodies by the presence of water and alcohol; moreover, he is of opinion that zinc-ethyl is dissolved by anhydrous ether without decomposition, and by the subsequent addition of water is transformed into oxide of zinc and methyl-gas.—Frankland considers it probable that, in the above-mentioned decomposition of iodide of ethyl by arsenic or tin, these metals unite with ethyl to form new radicals similar to kakodyl; in fact, the product of decomposition obtained by means of arsenic, possesses an odour analogous to that of kakodyl.—Iodide of methyl, iodide of ethyl, &c., are readily decomposed by phosphorus, and as no gas is evolved, it is probable that bases containing phosphorus are formed which are similar to those discovered by P. Thénard.(1)—Frankland has given a synopsis of the compounds of 1 or more equivs. of hydrogen, methyl, ethyl, &c., with 1 equiv. of zinc, arsenic, antimony, or phosphorus. The formation of these compounds he considers to be probable, and several of them which are marked with an asterisk \* have already been prepared.

Hydrogen-series.	Methyl-series.	Ethyl-series.	Propyl-series.	Butyl-series.	Amyl-series.	Phenyl-series.
H Zn	*( $C_2H_3$ ) Zn	*( $C_4H_5$ ) Zn	( $C_6H_7$ ) Zn	( $C_8H_9$ ) Zn	( $C_{10}H_{11}$ ) Zn	( $C_{12}H_{13}$ ) Zn
$H_2As$	*( $C_2H_3$ ) <sub>2</sub> As	( $C_4H_5$ ) <sub>2</sub> As	( $C_6H_7$ ) <sub>2</sub> As	( $C_8H_9$ ) <sub>2</sub> As	( $C_{10}H_{11}$ ) <sub>2</sub> As	( $C_{12}H_{13}$ ) <sub>2</sub> As
* $H_xSb$	( $C_2H_3$ ) <sub>x</sub> Sb	( $C_4H_5$ ) <sub>x</sub> Sb	( $C_6H_7$ ) <sub>x</sub> Sb	( $C_8H_9$ ) <sub>x</sub> Sb	( $C_{10}H_{11}$ ) <sub>x</sub> Sb	( $C_{12}H_{13}$ ) <sub>x</sub> Sb
* $H_3P$	*( $C_2H_3$ ) <sub>3</sub> P	( $C_4H_5$ ) <sub>3</sub> P	( $C_6H_7$ ) <sub>3</sub> P	( $C_8H_9$ ) <sub>3</sub> P	( $C_{10}H_{11}$ ) <sub>3</sub> P	( $C_{12}H_{13}$ ) <sub>3</sub> P

(1) Annual Report for 1847 and 1848, I, 497.

**Binoxisulphocarbonate of Ethyl.**—Desains(1) had obtained a compound  $C_6H_5S_4O_2$  as the only product of the action of iodine upon xanthate (xanthogenate) of potassa. Debus(2) has investigated the action of ammonia upon this compound. In order to prepare it, Debus recommends the employment of xanthate of potassa or of oxide of lead; the former he prepared according to the method of Sacc(3), and the latter by the following process:—To a solution of potassa in spirit of wine a quantity of bisulphide of carbon and hydrated protoxide of lead corresponding to the potassa employed is added, and the whole left from 6 to 8 hours, with frequent agitation. After this time has elapsed, a mixture is obtained of sulphide of lead with large colourless crystals of xanthate of lead; another portion of the latter is held in solution, and is separated from the filtrate on addition of water in long colourless needles. For the composition of xanthate of lead, Debus confirmed the formula  $PbO, C_6H_5S_4O$ ; the salt is insoluble in cold water, alcohol, and ether. It is decomposed by boiling water with separation of sulphide of lead, sulphide of ethyl, and probably dithionic acid. By dilute nitric acid it is transformed, after several hours, into a fatty substance, and by long contact or by concentrated acid into a yellow oil and sulphate of lead; it is not blackened by hydrosulphuric acid. At  $122^\circ$  the decomposition of this compound commences, and at  $140^\circ$ (4) a yellow oil distils over which possesses a variable boiling-point and is unaccompanied by the evolution of gas, whilst sulphide of lead remains behind and amounts in weight to half that of the salt employed.—When xanthate of lead is suspended in ordinary spirit of wine, and iodine is added until the liquid remains permanently brown, the solution becomes clear and colourless after the removal of the excess of iodine by a portion of xanthate of lead; if this liquid is now mixed with an equal volume of water and allowed to stand for 10 or 12 hours at a temperature of about  $12^\circ$  the compound discovered by Desains crystallises out. This compound, which Debus terms *binoxisulphocarbonate of ethyl*, crystallises in small white prisms which may easily be purified from a small portion of iodide of lead by recrystallisation. In preparing binoxisulphocarbonate of ethyl from xanthate of potassa the alcoholic liquid, after treatment with iodine, may immediately be diluted with water and allowed to remain at a temperature of  $12^\circ$ . By employing a concentrated alcoholic solution of xanthate of potassa, binoxisulphocarbonate of ethyl, after diluting its solution with water, separates as

Binoxisulphocarbonate of ethyl.

(1) Annual Report for 1847 and 1848, II, 18.

(2) Ann. Ch. Pharm. LXXII, 1; Laur. and Gerh. C. R. 1850, 50; Chem. Gaz. 1850, 143.

(3) Ann. Ch. Pharm. LI, 345; Berzelius' Jahresber. XXV, 771.

(4) Couerbe (Ann. Ch. Pharm. XL, 496) is stated to have obtained 8 per cent of gas in this manner.

Binoxisulphocarbonate of ethyl.

a yellow oil which becomes crystalline after several hours. Binoxisulphocarbonate of ethyl crystallises from dilute solutions in white concentrically-grouped shining prisms, frequently distorted to tables: its taste resembles that of mustard. It fuses at  $28^{\circ}$  to a yellowish peculiarly-smelling oil which only slowly resolidifies; after it has been heated from  $100^{\circ}$  to  $120^{\circ}$  the liquid does not crystallise again on cooling; and if it is heated to  $160^{\circ}$  it begins to decompose, as has already been stated by Desains. In the process of preparation this compound may be obtained as an uncrystallisable liquid by the too rapid addition of iodine, which raises the temperature too high. The composition of this body Debus found to be  $C_6H_5S_4O_2$ , which is the same as that at which Desains arrived. The former, however, writes the formula  $C_4H_5O$ ,  $C_2S_4O$ . It dissolves readily in ether and in anhydrous alcohol. Debus considers it probable that, on heating chloride of copper with xanthate of potassa, there is first of all formed a compound which is isomeric with binoxisulphocarbonate of ethyl. It is known that in this manner Zeise(1) obtained as the final result a compound of the composition of sulphocarbonate of ethyl. If the liquid, after treating the alcoholic solution of xanthate of potassa with chloride of copper, be filtered from the xanthate of suboxide of copper which is formed, and the filtrate mixed with water, an oily body is found to be precipitated. This substance dissolved in alcohol, but could not be crystallised even at  $0^{\circ}$ ; in its other properties, however, it agrees with binoxisulphocarbonate of ethyl.

When dry ammoniacal gas is passed into an alcoholic solution of binoxisulphocarbonate of ethyl, the liquid speedily becomes warm and cloudy with deposition of sulphur. As soon as the separation of sulphur has ceased, the current of gas is interrupted, the solution being then filtered, and the filtrate evaporated to dryness *in vacuo*. The residue effloresces almost entirely, and forms small clustered needles of xanthate of oxide of ammonium which are mixed with an oily body termed *xanthogenamide*. The latter may be removed by ether which after being evaporated leaves an oil possessing a garlic-like odour, and solidifying gradually at a temperature below  $28^{\circ}$ . 2 equivs. of binoxisulphocarbonate of ethyl and 2 equivs. of ammonia yield 2 equivs. of sulphur, 1 equiv. of xanthate of oxide of ammonium ( $NH_4O$ ,  $C_4H_5O$ ,  $2CS_2$ ), and 1 equiv. of xanthogenamide ( $C_6H_7NS_2O_2$ ).

The aqueous solution of xanthate of oxide of ammonium may be evaporated to dryness *in vacuo* without decomposition: by spontaneous evaporation in the air a small portion of the salt decomposes with formation of sulphocyanide of ammonium; in the water-bath the salt evaporates with the aqueous vapours. The crystals of the salt

(1) Kongl. Danske Vidensk. Selskabs naturvidensk. Afhandl. VI.

are lustrous, similar to those of urea, and when dried *in vacuo* over sulphuric acid have the composition  $\text{NH}_4\text{O}$ ,  $\text{C}_4\text{H}_5\text{O}$ ,  $2\text{CS}_2$ . If the salt be boiled for a short time only with ammonia it does not appear to be altered, but when left in contact for several days a small quantity of sulphide and sulphocyanide of ammonium are formed. With sulphide of ammonium the salt is decomposed either by ebullition or by lengthened contact with the formation of products which have not been farther investigated, but which are free from sulphocyanide of ammonium. When heated in a small tube a white sublimate is formed, together with sulphide of ammonium, a yellow, oily body, and probably also sulphocarbonate of ammonia, whilst a trifling black residue remains. By keeping the salt either in solution or in the dry form it decomposes with loss of ammonia.

Binoxisulphocarbonate of ethyl.

**Xanthogenamide.**—The preparation of *xanthogenamide* has been described above. The oily residue of the ethereal solution, which soon solidified, was obtained in large crystals of perfect purity from the solution in a small quantity of alcohol. If it is intended to prepare only xanthogenamide, it is sufficient to evaporate the alcoholic solution of binoxisulphocarbonate of ethyl, which has been treated with ammonia, in a water-bath, and to extract from the residue by means of water a small quantity of xanthate of oxide of ammonium which it still contains. When binoxisulphocarbonate of ethyl is treated with solution of ammonia for several days in the cold, or for 5 or 6 hours at from  $60^\circ$  to  $70^\circ$ , it dissolves with decomposition and separation of sulphur. The solution acquires a dark yellowish-brown colour in consequence of the formation of polysulphide of ammonium, and contains, in addition to xanthogenamide, xanthate of oxide of ammonium, or if digested for a longer period with excess of ammonia it contains the decomposition-products of the latter compound. On passing dry ammoniacal gas over dried binoxisulphocarbonate of ethyl at about  $70^\circ$ , the volatile products which are formed are bisulphide of carbon, sulphocarbonate of ammonia, sulphocyanide of ammonium, and sulphide of ammonium, whilst xanthogenamide, sulphur, and the greater part of the sulphocyanide of ammonium remain as residue. Xanthogenamide crystallises in monoclinometric pyramids + P. — P with 0 P; with a perfect cleavage parallel to the plane 0 P; the plane angles of 0 P are almost  $90^\circ$ ; 0 P : — P =  $118^\circ$ ; 0 P : + P =  $105^\circ$ . The crystals, when dried *in vacuo* over sulphuric acid, have the composition  $\text{C}_6\text{H}_7\text{NS}_2\text{O}_2$ ; they contain 2 equivs. of hydrosulphuric acid less than xanthate (xanthogenate) of oxide of ammonium, hence Debus has termed them xanthogenamide. The crystals fuse at about  $36^\circ$ , are not easily soluble in water, but are readily soluble in alcohol and ether. The solutions of this compound are neutral and not precipitated by the majority of metallic salts; precipitates, however, are produced by bichloride of platinum and by protochloride of mercury. The precipitate produced in the alcoholic solution by



Xanthogen-  
amide.

bichloride of platinum is yellow and crystalline, and is represented by Debus by the formula  $\text{PtCl}_2, \text{C}_6\text{H}_7\text{NS}_2\text{O}_3 + \text{PtCl}, \text{C}_6\text{H}_7\text{NS}_2\text{O}_3$ . Protoxides of mercury, silver, and lead decompose xanthogenamide with formation of a metallic sulphide and evolution of a body which powerfully affects the eyes; when the filtered liquid is distilled a portion of a neutral compound passes over, which cannot be separated, whilst in the residue there remains a small quantity of an ammonia-salt whose acid, after being set free by sulphuric acid, evolves the odour of cyanic acid. Concentrated sulphuric acid dissolves xanthogenamide, which may again be precipitated from its solution by water; when the solution is heated or allowed to stand for some time it evolves, without being blackened, a large quantity of sulphurous acid, and there remains in the solution, besides sulphuric acid, an acid which forms a soluble baryta-salt. Potassa-solution and baryta-water decompose xanthogenamide at the boiling temperature into alcohol and hydrosulphocyanic acid.—On submitting xanthogenamide to distillation it evolved a gas at  $110^\circ$ , and at  $175^\circ$  the fused mass entered into ebullition; by gradually depressing the temperature to  $152^\circ$  a colourless liquid possessing the odour of mercaptan and cyanic acid passed over and assumed a darker colour by exposure to light. This liquid, which is insoluble in water, but miscible with alcohol and with ether, exhibited on rectification a boiling-point varying from  $50^\circ$  to  $230^\circ$ . Its alcoholic solution yielded with protochloride of mercury a considerable precipitate, becoming crystalline in contact with the mother-liquor, and for which Debus has adduced the formula  $\text{C}_4\text{H}_5\text{S}, \text{HgS} + \text{HgCl}$ . In the distillation of xanthogenamide at the above-mentioned temperature there remained as residue a greyish-white mass which yielded crystals of cyanuric acid when recrystallised from the smallest possible quantity of hot alcohol.—Debus moreover adds, as the result of continued investigations, that xanthogenamide is probably to be considered either as  $\text{C}_4\text{H}_5\text{O}, \text{CNH}_2\text{O}, \text{CS}_2$ , or as  $\text{C}_4\text{H}_5\text{O}, \text{CNH}_2\text{O}, \text{CO}_2 + \text{C}_4\text{H}_5\text{S}, \text{CNH}_2\text{S}, \text{CS}_2$ .

**Salicylate of Oxide of Ethyl.**—Cahours(1) has prepared from salicylate of oxide of ethyl the substitution-product  $\text{C}_{18}\text{H}_8\text{Cl}_2\text{O}_6$ . If chlorine be passed into the ether heated to  $100^\circ$ , the liquid finally solidifies to a mass which, after being pressed between bibulous paper and recrystallised from alcohol, forms beautiful colourless tables of the above-mentioned composition.—Fuming nitric acid yields with salicylate of oxide of ethyl anilate of oxide of ethyl(2); on the other hand a mixture of fuming sulphuric and nitric acids yield therewith a compound  $\text{C}_{18}\text{H}_8(\text{NO}_4)_2\text{O}_6$ . This substance crystallises from boiling

(1) Ann. Ch. Phys. [3] XXVII, 461; J. Pr. Chem. XLIX, 281; Compt. Rend. XXVIII, 586 (in abstr.); Instit. 1849, 145; J. Pr. Chem. XLVII, 417.

(2) Ann. Ch. Phys. [3] X, 360; Berzelius' Jahresber. XXV, 767.

alcohol in yellowish-white plates, and, in the same manner as salicylate of oxide of ethyl, it forms with alkalies soluble and crystallisable compounds; by ebullition with caustic potassa it is decomposed into alcohol and dinitrosalicylate of potassa.

**Phenetole.**—When the perfectly dried compound of salicylate of oxide of ethyl with baryta is subjected to dry distillation a residue of carbonate of baryta remains, and a colourless liquid passes over; this liquid, which Cahours terms *phenetole*(1), is purified by washing with alkaline water, drying with chloride of calcium, and rectifying it. The composition of this substance is  $C_{16}H_{10}O_2$ ; it is lighter than water, boils at  $172^\circ$ , being  $20^\circ$  higher than the boiling-point of anisole (comp. p. 278), from which it differs by  $C_2H_2$ ; it is insoluble in water and readily soluble in alcohol and in ether. It is not altered by solution of potassa, but in concentrated sulphuric acid it dissolves with formation of a conjugated acid which yields a soluble and crystallisable salt with baryta. Chlorine and bromine form with it crystalline substances which have not yet been accurately investigated.

If phenetole is gradually mixed with an equal volume of fuming nitric acid a violent action takes place; on adding water to the reddish liquid which is thus formed a brown oil is separated; this oil is washed with alkaline water, then with pure water, and finally distilled. The boiling-point rises during the distillation; the first portion which distils is probably *nitrophenetole* ( $C_{16}H_9(NO_4)O_2$ ), whilst that which passes over last becomes crystalline, and is *dinitrophenetole* ( $C_{16}H_8(NO_4)_2O_2$ ). The latter is obtained in a state of purity when the mixture of phenetole with an equal volume of fuming nitric acid is allowed to boil for some minutes until the colour of the mixture becomes of a bright yellow; the oil which separates, on addition of water, is left to solidify, and the solid and washed mass is recrystallised from boiling alcohol. Dinitrophenetole thus prepared forms yellow needles similar to *dinitranisole* (page 278); when carefully heated they sublime without leaving a residue;

(1) The same compound has been obtained in a similar manner by Baly, who terms it *salithole* (Chem. Soc. Qu. J. II, 28; Ann. Ch. Pharm. LXX, 269; J. Pr. Chem. XLVII, 419). He found that salicylate of ethyl (boiling-point  $229^{\circ}5$ , sp. gr. 1.097) may be heated to perfect decomposition by contact with anhydrous baryta, and that it is advisable to add the salicylate of ethyl to the baryta only gradually, and in small quantities at a time. The compound of salicylate of ethyl with baryta yielded on distillation a brown liquid, consisting of phenetole (salithole) and phenole (phenylic acid), the latter being separable by water. For pure phenetole (salithole) he also found the composition  $C_{16}H_{10}O_2$ , and the boiling-point  $175^{\circ}$ . By the action of chlorine upon this substance he obtained a viscid mass which, after some weeks, exhibited an inclination to crystallise. By the action of bromine he obtained a heavy oil, which slowly solidified, and consisted of a mixture of several substitution-products. With fuming nitric acid he obtained the compound  $C_{16}H_8(NO_4)_2O_2$ , probably contaminated with  $C_{16}H_7(NO_4)_3O_2$ . This compound, which has also been prepared by Cahours, Baly terms *dinitrosalithole*.

**Phenetole.** but if more quickly heated they are decomposed with ignition, and leave a residue of carbon behind.—By passing sulphuretted hydrogen and ammonia into an alcoholic solution of dinitrophenetole a base is formed with deposition of sulphur. This base, which Cahours terms *nitrophenetidine*, crystallises from its alcoholic solution in brown needles similar to nitranisidine (page 279), and has the composition  $C_{16}H_{10}(NO_4)NO_2$ . It forms crystallisable salts with sulphuric and hydrochloric acids, and departs itself with chloride of benzoyl in the same manner as nitranisidine.

**Hydrate of Oxide of Amyl.**—It appears from Reynolds's(1) investigations, of which only a short note has yet been published, that on passing the vapour of fusel-oil through a red-hot tube, a mixture of gases is formed which possesses an aromatic odour and varies in composition according to the degree of heat employed, whilst a portion of carbon is deposited. If the decomposition is effected at a dull red heat, the gaseous mixture is found to contain principally a gas of the composition  $C_6H_6$ , and hydrogen; Reynolds proposes to term the former *propylene*. When the mixture of gases is passed into bromine, a heavy compound is formed, boiling at  $145^\circ$ , and of the composition  $C_6H_6Br_2$ ; this substance, which is analogous to bromide of elayl, exhibits a similar comportment with solution of potassa. Propylene forms with chlorine a compound corresponding with chloride of elayl (oil of olefiant gas), having the composition  $C_6H_6Cl_2$ , and boiling at  $103^\circ$ ; it is only with difficulty obtained free from compounds containing a larger proportion of chlorine.

**Oxide of Amyl.**—Malaguti(2) has studied the action of chlorine upon Balard's amylic ether (oxide of amyl), under the influence of solar irradiation and of elevated temperatures. The product obtained, after the completion of the operation, imparted strongly-acid properties to water; and the aqueous solution thus formed yielded, on evaporation *in vacuo*, a considerable quantity of chloroacetic acid.—The product, after being washed with water, was treated with an alcoholic solution of potassa; as soon as heat was applied a violent action took place, accompanied by a blackening of the mixture and the formation of a large quantity of chloride of potassium. On adding water to the alcoholic liquid a dark-coloured oil slowly separated, and when allowed to remain at rest deposited sesquichloride of carbon ( $C_4Cl_6$ ), which generally appeared to be a mixture of different compounds. The alcoholic liquid, diluted with water, contained valeric acid and its chlorinated products of substitution. The remaining liquid on which potassa produced no farther action, consisted chiefly of sesquichloride of carbon and chloraldehyde ( $C_4Cl_4O_2$ ). Malaguti believes that the two latter substances are the principal products

(1) J. Pharm. [3] XVI, 399; Ann. Ch. Pharm. LXXI, 119 (in part).

(2) Ann. Ch. Phys. [3] XXVII, 417; J. Pr. Chem. XLIX, 291.

of the decomposition of the simple ethers, in which all the hydrogen is replaced by chlorine, when subjected to an excess of chlorine.

**Cyanate of Amyl.**—Wurtz (1) has prepared cyanate of amyl, by distilling 2 parts of sulphamylate of potassa with 1 part of cyanate of potassa. If mercury be added to effect a more equal distribution of heat, the mixture may be rapidly distilled over an open fire. The distillate is oily, and when a considerable quantity of cyanate of amyl is present, it is pretty fluid; the cyanate of amyl boiling at about  $100^{\circ}$ , is separated by rectification from the less volatile oily substance. Cyanate of amyl dissolves in an aqueous solution of ammonia, and on evaporating the solution, a compound is obtained of the composition  $C_{12}H_{14}N_2O_2$ , which crystallises in long plates, and is termed by Wurtz *amylourea*.—We may here call to mind that Wurtz terms the compound  $C_4H_6N_2O_2$  *acetylurea*, and  $C_6H_8N_2O_2$  *metacetylurea*, as was mentioned in the Annual Report for 1847-8, II, 9, 19.

Medlock (2) has published investigations upon various compounds of the amyl-series. The hydrated oxide of amyl employed in his experiments had been obtained in the distillation of corn-spirit, and contained only spirit of wine and water, from which it was separated in the ordinary manner.

**Sulphocyanide of Amyl.**—Medlock prepared sulphocyanide of amyl, which had previously been obtained in an impure state by O. Henry, jun. (3), by distilling an intimate mixture of 2 parts of sulphamylate of lime with 1 part of sulphocyanide of potassium, rectifying the oily liquid which distilled over with water, drying with chloride of calcium to remove the last traces of water, which it retained most pertinaciously, and subsequently rectifying it several times. Medlock found it necessary to dry the two salts as much as possible, in order to avoid a strong intumescence. Sulphocyanide of amyl,  $C_{10}H_{11}C_2NS_2$ , thus obtained, is a light-yellow oily liquid, which becomes darker by exposure to the air; it is miscible with alcohol and ether, nearly insoluble in water, and has a constant boiling-point of  $197^{\circ}$ .—If sulphocyanide of amyl be repeatedly distilled with nitric acid until it has disappeared, and the nitric acid be expelled from the residue by evaporation on a water-bath, a red liquid possessing a garlic odour remains behind. This liquid contains *hyposulphamylic acid*, which forms a crystallisable lead-salt, and from which the acid may be separated by hydrosulphuric acid. The aqueous solution of hyposulphamylic acid, when evaporated in a water-bath, left the acid as a colourless liquid, which *in vacuo* over sulphuric acid was slowly converted into a granular, crystalline mass,

Cyanat  
of  
amyl.

(1) Instit. 1849, 258.

(2) Chem. Soc. Qu. J. I, 368; Ann. Ch. Pharm. LXIX, 214.

(3) Annual Report for 1847 and 1848, II, 26.

Sulpho-  
cyanide of  
amyl.

which deliquesced when exposed to the air. Hyposulphamylic acid is decomposed when heated; it corresponds to hyposulphomethylic acid(1), and to hyposulphethylic acid(2), which have been described at a former period. It forms salts of the general formula,  $\text{RO}, \text{C}_{10}\text{H}_{11}\text{S}_2\text{O}_5$ (3). The baryta-salt crystallises in readily-soluble lustrous scales, the copper-salt in plates, and the lead-salt in readily-soluble, silky needles; all three salts are free from water of crystallisation.

**Chlorocarbonate, and Carbonate of Amyl.**—Hydrated oxide of amyl absorbed phosgene-gas with great avidity, and with considerable development of heat, 1 grm. absorbing about 1 litre of gas. When perfectly saturated, a large quantity of hydrochloric acid was evolved, and the yellow liquid separated into two strata, the lower of which consisted of accidental water, strongly impregnated with hydrochloric acid. The upper stratum, which possessed a disagreeable odour, was agitated with an equal volume of water, separated by a pipette, and digested with protoxide of lead, in order to remove every trace of hydrochloric acid. When dried over chloride of calcium and distilled, the liquid blackened, and evolved a large quantity of carbonic and hydrochloric acid, whilst the boiling-point rose rapidly from  $150^\circ$  to  $224^\circ$ . The last portion of the distillate, boiling at  $224^\circ$ , is a liquid of an agreeable odour, which has the sp. gr. 0.9144, and the composition  $\text{C}_{11}\text{H}_{11}\text{O}_3 = \text{C}_{10}\text{H}_{11}\text{O}, \text{CO}_2$ . It is *carbonate of amyl*, as was proved also by its deportment with an alcoholic solution of potassa, with which it immediately formed hydrated oxide of amyl and carbonate of potassa. Medlock is of opinion that chlorocarbonate of amyl is the first product formed by the action of phosgene-gas upon hydrated oxide of amyl ( $\text{C}_{10}\text{H}_{11}\text{O}, \text{HO} + 2 \text{COCl} = \text{HCl} + \text{C}_{10}\text{H}_{11}\text{O}, \text{C}_2\text{ClO}_3$ ); this compound, however, in the presence of water, is immediately split into hydrochloric acid, carbonic acid, and carbonate of amyl(4) ( $\text{C}_{10}\text{H}_{11}\text{O}, \text{C}_2\text{ClO}_3 + \text{H}_2\text{O} = \text{C}_{10}\text{H}_{11}\text{O}, \text{CO}_2 + \text{HCl} + \text{CO}_2$ ). If the above-mentioned disagreeably-smelling stratum of liquid was not washed with water, but imme-

(1) Annual Report for 1847 and 1848, II, 4.

(2) Annual Report for 1847 and 1848, II, 16.

(3) In a note to Medlock's paper, A. W. Hofmann considers it probable that hyposulphamylic acid may be identical with sulphamylsulphuric acid. To represent the composition of the baryta-salt of the latter acid, Gerathewohl and Erdmann, and likewise O. Henry, jun., gave the formula  $\text{BaO}, \text{C}_{10}\text{H}_{11}\text{S}_2\text{O}_5 + \text{H}_2\text{O} = \text{BaO}, \text{C}_{10}\text{H}_{11}\text{S}_2\text{O}_6$ . The former chemists (J. Pr. Chem. XXXIV, 447) prepared the acid by the action of nitric acid upon amyl-mercaptan. O. Henry, jun. (Annual Report for 1847 and 1848, II, 26) obtained it by treating bisulphide, or sulphocyanide of amyl, with nitric acid.

(4) In a note to Medlock's paper A. W. Hofmann states, that according to some experiments made by Bloxam the chlorocarbonate of ethyl suffers, when distilled with water, an analogous decomposition, which, however, is imperfectly accomplished even after repeated distillation; a circumstance which prevents this reaction being employed as a convenient method of preparing the carbonate of ethyl.

diately freed from hydrochloric acid by protoxide of lead, and distilled, the quantity of water which was produced by this method of purification was sufficient to cause the same decomposition into carbonate of amyl. Medlock, however, believes that chlorocarbonate of amyl actually exists, especially as the crude product of the action of phosgene-gas upon hydrated oxide of amyl, when treated with an alcoholic solution of ammonia, yielded a white precipitate of chloride of ammonium, and a white substance which was unctuous to the touch and resembled spermaceti. This substance is almost insoluble in water, and appears to be amylo-urethane—a body in the amyl-series corresponding to urethane (carbamate of ethyl), which is formed by the action of ammonia upon chlorocarbonate of ethyl.

Chlorocarbonate, and carbonate of amyl.

**Amylo-Urethane.**—In reference to the latter point, Medlock has subsequently(1) published the following details:—Pure hydrated oxide of amyl was introduced into a large glass balloon filled with dry phosgene-gas. A portion of the amber-coloured liquid was immediately distilled in a dry retort; it entered into ebullition at  $180^{\circ}$ , the boiling-point rapidly rose to  $224^{\circ}$ , where it remained pretty constant. The liquid which passed over at this temperature, as well as the residue remaining in the retort which was mixed with carbonaceous matter, was no longer solidified by ammonia; hence it appears that chlorocarbonate of amyl is likewise, decomposed by heat alone, into carbonate of amyl.—The portion of the amber-coloured liquid which was not heated, entered into ebullition when mixed with an aqueous solution of ammonia; the oily liquid floating upon the surface solidified on cooling to a crystalline mass, which was purified by pressure between bibulous paper, and by washing with water. This compound is *amylo-urethane*, or carbamate of amyl  $C_{12}H_{13}NO_4 = C_{10}H_{11}O, C_2NH_2O_3$ . It is soluble in alcohol, ether, and in boiling water, and crystallises from the latter solution, on cooling, in satiny iridescent needles; it fuses at  $60^{\circ}$ , and volatilises without decomposition at  $220^{\circ}$ . When distilled with caustic baryta, it is decomposed, with formation of ammonia, carbonic acid, and an oily product, which has the odour and boiling-point of hydrated oxide of amyl. Amylo-urethane is perfectly dissolved by sulphuric acid in the cold, and even after several days it is not decomposed; it may be separated again on addition of water; if, however, the solution is heated the compound is converted into sulphamylic acid and ammonia, with evolution of carbonic and sulphurous acids.

In connection with this subject, Wurtz(2) calls to mind that he had prepared urethane by the action of liquid chloride of cyanogen upon alcohol(3). He had found that by acting upon hydrated oxide

(1) Chem. Soc. Qu. J. II, 212; Ann. Ch. Pharm. LXXI, 104.

(2) J. Pharm. [3] XVII, 79.

(3) Compt. Rend. XXII, 503; J. Pr. Chem. XXXVIII, 228.

Ethereal  
oils.

of amyl with liquid chloride of cyanogen, amylo-urethane is readily formed in quantity; he likewise found it to possess the same composition, as has been assigned to it by Medlock.

**Ethereal Oils.**—Regarding a lengthened investigation of Zeller(1) on ethereal oils, their colour, odour, taste, consistence, deportment towards light, heat and cold, sp. gr., reaction upon litmus, deportment with iodine, nitric acid, sulphuric acid, and chromate of potassa, alcoholic solutions of potassa and ammonia, their solubility in alcohol, their adulterations, &c., we must refer to the original memoir.

**Bitter Almond-oil.**—In opposition to his earlier views(2), Lepage(3) now admits that bitter almond-oil, and hydrocyanic acid, are for the most part formed by the action of cold or lukewarm water upon the leaves of bitter laurel. On adding the leaves to boiling water, the distillate is found to contain no trace of oil and but little hydrocyanic acid; but on digesting the same leaves with cold water and subsequently distilling, large quantities of both are contained in the distillate.—Guibourt(4) asserts that he has decisively proved that neither hydrocyanic acid nor oil exist in the fresh and perfect leaves of the bitter laurel.

B. Quadrat(5) has investigated the products which are formed by the action of bisulphide of carbon and ammonia upon bitter almond-oil. On mixing these two compounds, two layers are formed; the upper one gradually acquires a red colour, and when mixed with acid evolves hydrosulphuric acid, whilst a yellow substance, soluble in potassa, is deposited. In the lower stratum colourless crystals, generally of a granular appearance, are formed, and are again dissolved if allowed to remain a considerable time in the mother-liquor. These crystals are obtained in a state of purity by pressure between paper, and washing them with ether; they are readily decomposed, and become yellow when exposed to the air; they are possessed of a peculiar odour and bitter taste. Quadrat considers this compound to be  $C_{16}H_5NS_2$ , and in reference to its deportment with sesquichloride of iron, terms it *sulphocyanide of benzoyl*. When brought into contact with sesquichloride of iron sulphocyanide of iron is formed, whereby the liquid acquires a blood-red colour; if heated, bitter almond-oil distils over. According to this decomposition, which Quadrat represents by the equation  $3 C_{16}H_5NS_2 +$

(1) Jahrb. Pr. Pharm. XVIII, 1, 73, 153, 217, 281, 353; XIX, 1, 65.

(2) Annual Report for 1847 and 1848, II, 34.

(3) J. Pharm. [3] XV, 274.

(4) J. Pharm. [3] XV, 276.

(5) Ann., Ch. Pharm. LXXI, 13.

$\text{Fe}_2\text{Cl}_3 + 6 \text{HO} = \text{Fe}_2, 3 \text{CyS}_2 + 3 \text{HCl} + 3 \text{C}_{14}\text{H}_6\text{O}_2$ , the crystallised body may be regarded as  $\text{C}_{16}\text{H}_5\text{NS}_2$ , a compound of sulphocyanogen  $\text{C}_2\text{NS}_2$ , with the carbohydrogen  $\text{C}_{14}\text{H}_5$ , which Quadrat considers to be the radical of the benzoyl-series. Its formation is explained by the equation  $2 \text{CS}_2 + 3 \text{NH}_3 + \text{C}_{14}\text{H}_6\text{O}_2 = \text{C}_{16}\text{H}_5\text{NS}_2 + 2 \text{NH}_4\text{S} + 2 \text{HO}$ .—When boiled with alcohol, sulphocyanide of benzoyl, with the co-operation of the elements of water and assimilation of oxygen, is split into carbonic acid, ammonia, hydrosulphuric acid, sulphur, and a white compound, which is deposited in plates, and for which Quadrat has adduced the formula  $\text{C}_{56}\text{H}_{24}\text{N}_2\text{S}_5$  ( $4 \text{C}_{16}\text{H}_5\text{NS}_2 + 12 \text{HO} + 4 \text{O} = \text{C}_{56}\text{H}_{24}\text{N}_2\text{S}_5 + 2 \text{NH}_3 + 2 \text{HS} + 8 \text{CO}_2 + \text{S}$ ). If a hot alcoholic solution of sulphocyanide of benzoyl be mixed with a little ammonia, and a sufficient quantity of water be added to cause a permanent turbidity, a white powder is separated on cooling. For this compound, which is insoluble in water, and is decomposed by alcohol, Quadrat has adduced the formula  $\text{C}_{56}\text{H}_{26}\text{N}_2\text{S}_5$ , differing from the preceding only by 2 equivs. of hydrogen. Both these bodies still require a more careful investigation, in order to establish their chemical constitution.—At  $120^\circ$  sulphocyanide of benzoyl fuses, and is split into bisulphide of carbon, ammonia, and bitter almond-oil, part of which distils over undecomposed; at  $150^\circ$  the contents of the retort become very liquid, and the evolution of gas ceases. At a temperature of from  $210^\circ$  to  $220^\circ$  a small quantity of a substance, crystallising in needles, passes over; if the application of heat be now interrupted, and the yellowish residue after it has become cold be treated with alcohol, a crystalline compound remains undissolved, whilst another yellow, resinous compound is taken up in solution. The first of these substances, which is insoluble in alcohol, according to the statements of Quadrat, closely approximates in its properties to the nitride of benzoyl,  $\text{C}_{14}\text{H}_5\text{N}$ , which has been described by Laurent; it contains, however, 1 equiv. of carbon more, and its formula is  $\text{C}_{15}\text{H}_5\text{N}$ , according to which the formation of this body from sulphocyanide of benzoyl is explained by the simple elimination of bisulphide of carbon. The resinous product of decomposition, which was soluble in alcohol, could not be obtained in a state of purity.—Proceeding from the fact of the existence of the sulphocyanogen-compound  $\text{C}_{16}\text{H}_5\text{N}$ , Quadrat has arrived at the same expression for the constitution of amygdalin as Wöhler, whose views have already been detailed in the Annual Report for 1847 and 1848, II, 117.

**Rose-oil. Lavender-oil.**—Guibourt(1) has published some observations regarding the means of recognising the purity of rose-oil; and Bell(2) upon the preparation of lavender-oil.

(1) J. Pharm. [3] XV, 345; Arch. Pharm. [2] LXI, 321.

(2) Pharm. J. Trans. V111, 276; J. Chim. Méd. [3] V, 487.



Rue-oil.

**Rue-oil.**—R. Wagner(1) states that on heating a mixture of cod liver-oil and concentrated sulphuric acid with an alkali, a penetrating odour is evolved resembling that of rue-oil, and that on distilling with water a very small quantity of a bright-yellow oil passes over, which possesses this odour, boils at  $300^{\circ}$ , and is lighter than water. Amongst the volatile fatty acids of cod liver-oil, he found butyric, and capric acid; and moreover, he re-states the fact, that rue-oil may be considered as the aldehyde of capric acid(2). A mixture of cod liver-oil and sulphuric acid, saturated with lime, which had been allowed to stand several days previous to being distilled, yielded a milky distillate possessing the odour of crisp mint.

**Furfurole.**—Döbereiner(3) has published some observations confirmatory of Fownes' and Cahours' statements(4) regarding furfurole.

**Volatile Oil of Horse-Raddish.**—On investigating the pungent ethereal oil of fresh horse-raddish root, Winckler(5) has found that the unsliced roots lose their pungency, when heated in a water-bath for some hours with spirit of wine, in such a manner as to allow the volatilised spirit to return to the vessel. The portion of spirit of wine which first passed over was devoid of pungent taste, and was also free from ethereal oil. These roots, when sliced and boiled with the same spirit of wine, yielded a liquid which deposited on evaporation a dirty-green fat; the filtrate from this substance yielded on evaporation a brownish-yellow residue, from which alcohol of 80 per cent dissolved a brownish-yellow, amorphous body, and left behind a portion of sugar. The former substance, when dissolved in water, and treated with myrosine from mustard, and more especially when mixed with a very small quantity of an alkali, soon evolved a quantity of pungent oil of horse-raddish.—On agitating the above-mentioned brownish-yellow residue with alcohol, and decanting the liquid, a white pulverulent substance may be separated from the smeary residue. According to Winckler, the first is a compound of uncrystallisable sugar and potassa, and probably existed in combination with myronic acid in the horse-raddish. The latter, when dissolved in water, immediately forms with myrosin pungent horse-raddish-oil, but still contains a portion of sugar and potassa. Winckler moreover states, that a preparation similar to the above-mentioned sugar-potassa compound may be obtained by agitating for some time a portion of Dutch syrup with eight times its weight of absolute alcohol, decolourising the alcoholic solution with animal charcoal, and

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(1) J. Pr. Chem. XLVI, 155.

(2) Annual Report for 1847 and 1848, II, 42.

(3) Arch. Pharm. [2] LVIII, 1; J. Pr. Chem. XLVI, 167.

(4) Annual Report for 1847 and 1848, II, 50.

(5) Jahrb. Pr. Pharm. XVIII, 96; Chem. Gaz. 1849, 421.

mixing it with a solution of potassa in alcohol. White sugar-potassa separates, and, in the absence of free potassa, dissolves in hot alcohol without decomposition; but when exposed to the air, it is rapidly decomposed. Regarding the preparation of myronic acid from horse-raddish, Winckler(1) moreover states, that the best method is to mix well-washed yeast with the residue of the alcoholic extract of horse-raddish, after it has been repeatedly treated with absolute alcohol. By this process the sugar is destroyed by fermentation, and the liquid then yields on evaporation a brownish-yellow, syrupy mass, containing, according to Winckler, acid myronate of potassa, and forming a pungent oil with myrosin.—These statements render a more comprehensive investigation, leading to more definite results, highly desirable.

Volatile  
oil of  
horse-  
raddish.

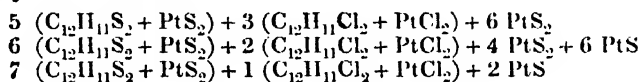
**Assafoetida-oil.** — Hlasiwetz(2) has investigated the oil of assafoetida.—Assafoetida of commerce contains a gummy body, a resin, and a volatile oil; the two latter constituents are dissolved by strong spirit of wine. The largest quantity of oil, amounting at most to half an ounce from a pound, is obtained from assafoetida by distilling the pulverised gum with water, in a glass vessel heated in a bath consisting of a solution of salt. The oil which passes over is pale-yellow, mobile, and has a powerful odour; it dissolves with facility in spirit of wine and in ether, and likewise in considerable quantity in water. The oil is neutral to test paper, and, like the crude assafoetida, evolves on long standing a large quantity of hydrosulphuric acid. It does not even partially solidify when placed in a freezing mixture; it boils at from  $135^{\circ}$  to  $140^{\circ}$ , being thereby decomposed with evolution of hydrosulphuric acid. On standing for some time exposed to the atmosphere, it becomes slightly acid, and acquires a different odour; in the fresh state, it is free from oxygen. The crude oil obtained in different operations contained from 64.2 to 69.3 per cent of carbon, from 9.1 to 10.5 hydrogen, and from 20.2 to 25.4 sulphur. Hlasiwetz considers the crude oil to be a mixture of  $C_{12}H_{11}S_2$  and  $C_{12}H_{11}S$ , in variable proportions.—On distilling the oil while a current of ammonia-gas is passing through it at  $150^{\circ}$ , white lustrous crystalline laminae of sulphide of ammonium, volatile by the heat of the hand, are deposited in the neck of the retort. When the oil is heated with protosulphide of potassium to  $150^{\circ}$ , or with pentasulphide at  $185^{\circ}$ , a lively evolution of hydrosulphuric acid takes place, whilst the oil invariably acquires a darker colour, which is due to the presence of dissolved sulphur. Hydrochloric acid gas changes the colour of the oil from red and violet into black, and renders it semi-fluid. Chlorine produces the same change of colours with evolution of hydrochloric acid and chloride of sulphur,

(1) Jahrb. Pr. Pharm. XVIII, 101.

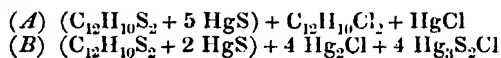
(2) Ann. Ch. Pharm. LXXI, 23; Chem. Gaz. 1850, 108.

Assafœ-  
tida-oil.

and formation of a tarry mass. Potassium, when brought into contact with the oil, gives rise to an evolution of gas and formation of sulphide of potassium. The remaining oil, with an amount of sulphur reduced to about 9.1 per cent, possesses an aromatic odour. The oil forms, with an excess of protoxide of silver, a black mixture, which at as low a temperature as  $100^{\circ}$  commences to boil, water being simultaneously formed. The oil which distils off has the same composition as the crude oil; it was found to contain 65.6 per cent of carbon, 10.1 hydrogen, and 24.8 sulphur.—The alcoholic solution of the crude oil yields, with bichloride of platinum, yellow or brown precipitates, varying in composition, according to the concentration and temperature of the liquids and the time the action is continued. Hlasiwetz expresses the composition of three precipitates which he prepared by the formulæ



and he considers the uncombined bisulphide and protosulphide of platinum which are here represented only as accidental admixtures.—Concentrated alcoholic solutions of the crude oil and protochloride of mercury yield a white flocculent precipitate, which afterwards assumes a grey colour, from the formation of sulphide of mercury. The liquid possesses a garlicky odour, and has an acid reaction; at the same time a somewhat greasy mass is formed by the action of hydrochloric acid upon the oil. If the precipitate is boiled with concentrated spirit of wine, the solution which is formed deposits on cooling a white salt (*A*), in microscopic crystals; whilst the boiling spirit leaves a greyish-white powder (*B*) undissolved. Hlasiwetz assigns to these compounds the following formulæ:



and endeavours, by halving the formulæ, to connect them with the allyl-series ( $\text{C}_6\text{H}_5$ ). If one of these compounds be rubbed with sulphocyanide of potassium, a powerful odour of mustard-oil is evolved, and a few drops of the oily liquid which passes over on application of heat, yield, on addition of ammonia, crystals resembling those of mustard-oil-ammonia.—A volatile oil, of the odour of rosemary, and of the composition  $\text{C}_{48}\text{H}_{44}\text{S}_9$ , or  $\text{C}_{48}\text{H}_{45}\text{S}_9$ , is formed by the repeated action of a concentrated mixture of protoxide of lead and potassa upon the crude oil, or by continued digestion of the crude oil with moist hydrated oxide of lead; the same compound is likewise formed by passing sulphurous acid into the crude oil, or by the prolonged action of soda-lime upon the oil at a temperature of  $200^{\circ}$ . In the latter case, hydrosulphuric acid is also evolved, and the residue is found to contain valeric and

propionic acids, which are likewise present in the water distilled with assafoetida; these acids, however, are not produced in the dry distillation of the resin, nor of the gummy constituents of the assafoetida. On treating the crude oil with solid caustic soda at  $120^{\circ}$ , a large quantity of hydrosulphuric acid is evolved, and the residue contains formic and a small quantity of acetic acid; the residue, when dissolved in water, deposits an oil which yielded on analysis 76.9 per cent of carbon, 11.4 hydrogen, and 11.6 sulphur; from which numbers Hlasiwetz has calculated the formula  $C_{36}H_{33}S_2$ .—Concentrated nitric acid acts violently on the crude oil, sometimes even producing inflammation; on slowly adding the acid, and finally boiling the mixture, an orange-yellow liquid is obtained, which, on dilution with water, deposits a resin; the distillate of the diluted liquid contains acetic and propionic acids, and the residue oxalic acid.—Acetic and propionic acids are likewise formed by the oxidation of the crude oil with chromic acid.—The resin of assafoetida, precipitated by water from the concentrated alcoholic solution, which has been obtained by treating assafoetida with spirit of wine, is yellowish-white, but soon acquires a rose-colour by exposure to the air; it dissolves in concentrated sulphuric acid with a red colour. When subjected to dry distillation, it yields consecutively a green, blue, violet, and red oily distillate, possessing an aromatic odour. The violet-coloured distillate dissolves in potassa-solution, with an intense rose-red colour; the oil which distilled over yielded to potassa formic acid and traces of acetic acid.—The gummy constituent of assafoetida yielded on distillation formic acid, and a small portion of acetic acid.

**Naphthalin-Compounds.**—Laurent(1) has published investigations upon several compounds of naphthalin.—The action of concentrated sulphuric acid upon naphthalin,  $C_{20}H_{18}$ , gives rise to the formation of two acids; one of these acids, which forms a lead-salt insoluble in alcohol, Berzelius represented by the name *naphthin-hyposulphuric acid*, and considered it to be expressed by the formula  $C_{11}H_{11}O$ ,  $S_2O_5 + HO$ . Laurent terms this acid *thionaphthalic acid*; he found that its lead-salt dried at  $220^{\circ}$ , had the composition  $2PbO$ ,  $C_{20}H_6(SO_2)_2$ ,  $2SO_3$ , and that the salt, dried at  $100^{\circ}$ , still contained 4 equivs. of water. He found that the amount of hydrogen contained in the lead-salt of the acid, formerly termed *naphthalin-hypo-sulphuric acid*, and which he now terms *sulphonaphthalic acid*, corresponded to the formula  $PbO$ ,  $C_{20}H_7(SO_2)$ ,  $SO_3$ . The results are confirmatory of the investigations made by Faraday and Regnault.—*Nitro-sulphonaphthalic acid*, produced by the action of sulphuric acid upon *nitronaphthalin*,  $C_{20}H_7(NO_2)$ , he found to be identical with the compound  $HO$ ,  $C_{20}H_6(SO_2)(NO_2)$ ,  $SO_3$ , which is

(1) Laur. and Gerh. C. R. 1849, 390; Ann. Ch. Pharm. LXXII, 297 (in abstr.)

Naphthalin-compounds.

formed by the action of nitric acid upon sulphonaphthalic acid. Laurent was unsuccessful in his attempt to prepare dinitro-sulphonaphthalic acid,  $\text{HO}, \text{C}_{20}\text{H}_5(\text{SO}_2)(\text{NO}_2)_2, \text{SO}_3$ , from dinitro-naphthalin,  $\text{C}_{20}\text{H}_6(\text{NO}_2)_2$ .—*Chloro-sulphonaphthalic acid*,  $\text{HO}, \text{C}_{20}\text{H}_5(\text{SO}_2)\text{Cl}, \text{SO}_3$ , and *dischloro-sulphonaphthalic acid*,  $\text{HO}, \text{C}_{20}\text{H}_5(\text{SO}_2)\text{Cl}_2\text{SO}_3$ , had already been prepared and analysed by Zinin(1).—Laurent has now investigated also *bromo-sulphonaphthalic acid*,  $\text{HO}, \text{C}_{20}\text{H}_5(\text{SO}_2)\text{Br}, \text{SO}_3$ . In order to prepare this compound bromonaphthalin ( $\text{C}_{20}\text{H}_7\text{Br}$ ) is heated with fuming sulphuric acid; after the completion of the action the solution is diluted with water and neutralised with potassa; when filtered and allowed to cool a crystalline magma separates, from which the bromo-sulphonaphthalate of potassa,  $\text{KO}, \text{C}_{20}\text{H}_5(\text{SO}_2)\text{Br}, \text{SO}_3$ , is extracted by boiling alcohol. This salt is colourless, slightly soluble in cold water, but is moderately soluble in hot water and in alcohol. It forms nodular crystals and yields with chloride of barium, when hot concentrated solutions are employed, a precipitate of the corresponding baryta-salt which is but little soluble in cold water; by the action of boiling nitric acid a yellow salt is obtained which is only slightly soluble in water, and probably is represented by the composition  $\text{KO}, \text{C}_{20}\text{H}_5(\text{SO}_2)\text{Br}(\text{NO}_2), \text{SO}_3$ .—The potassa-salt of *dibromo-sulphonaphthalic acid*,  $\text{KO}, \text{C}_{20}\text{H}_5(\text{SO}_2)\text{Br}_2, \text{SO}_3$ , was prepared from dibromonaphthalin,  $\text{C}_{20}\text{H}_6\text{Br}_2$ , in precisely the same manner. It is similar to the preceding compound.—When trichloronaphthalin, ( $\text{C}_{20}\text{H}_5\text{Cl}_3$ ) is dissolved in hot fuming sulphuric acid, the solution diluted with water and saturated with potassa, a copious gelatinous mass is formed; when heated to ebullition and filtered, even a very dilute solution of this compound solidifies on cooling to a gelatinous mass which consists of delicate microscopic needles. The solution of this salt in hot water produces with acetate of lead a gelatinous precipitate of a lead-salt consisting of microscopic needles, by the decomposition of which with sulphuric acid *trichloro-sulphonaphthalic acid* is obtained. Its aqueous solution solidifies on cooling to a jelly, but from a hot alcoholic solution it separates as a crystalline magma. It decomposes the chlorides, and even nitrate and sulphate of potassa or soda. The salts of this acid have the composition  $\text{RO}, \text{C}_{20}\text{H}_4(\text{SO}_2)\text{Cl}_3, \text{SO}_3$ ; if the ammonia-salt is mixed with acetate of copper, ammonia being added, and the mixture heated, a lilac-coloured salt separates on cooling in gelatinous fibres,  $\text{CuO}, \text{C}_{20}\text{H}_4(\text{SO}_2)\text{Cl}_3, \text{SO}_3 + 2 \text{NH}_3 + 4 \text{HO}$ .—*Tetrachloro-sulphonaphthalic acid* is formed by dissolving tetrachloro-naphthalic ( $\text{C}_{20}\text{H}_4\text{Cl}_4$ ) in fuming sulphuric acid; the solution, when diluted with water and saturated with potassa, deposits on cooling the potassa-salt  $\text{KO}, \text{C}_{20}\text{H}_3(\text{SO}_2)\text{Cl}_4, \text{SO}_3$  in crystalline flocks.

Laurent moreover appends to these investigations some the-

oretical considerations regarding which we must refer to the original memoir. Benzole.

**Benzole.**—Laurent and Gerhardt(1) have investigated several nitrogenous compounds derived from benzole, which they regard, together with dinitro-diphenamic acid (page 240), as belonging to the diphenic-series. By the latter term they signify the compounds which are derived from two atoms of benzole ( $C_{12}H_6$ ) or phenole ( $C_{12}H_6O_2$ ) united into one atom.—Mitscherlich(2) formerly described a compound  $C_{12}H_5N$  or  $C_{24}H_{10}N_2$  (azobenzide) which was obtained by distilling nitrobenzide ( $C_{12}H_5NO_4$  or  $C_{24}H_{10}N_2O_8$ ) with an alcoholic solution of potassa.—Zinin(3) has subsequently shown that in this process another compound (azoxybenzide) is formed which is expressed either by the formula  $C_{12}H_5NO$  or by  $C_{24}H_{10}N_2O_2$ . This observation of Zinin has been confirmed by Laurent and Gerhardt.—The experiments of these chemists prove that azoxybenzide when boiled with nitric acid is converted into a yellow substance, which is slightly soluble in boiling alcohol or ether. This compound separates from these solutions in yellow crystalline flocks, and from the nitric acid solution in small needles. The composition of this body, which may be termed *nitro-azoxybenzide*, is  $C_{24}H_9(NO_4)N_2O_2$ . It is rapidly attacked by an alcoholic solution of potassa, when warmed, with the formation of a reddish-brown solution which yields a precipitate of the same colour on addition of water. This precipitate, after being washed with alcohol and dried, is dissolved in boiling turpentine-oil, and the solution filtered while hot, when a crystalline orange-red powder is deposited, which is washed with ether. It is almost insoluble in alcohol and ether, and according to Laurent and Gerhardt has the composition  $C_{24}H_9N_3O_2$ . The formula requires 68.2 per cent of carbon, 4.2 hydrogen, and 19.9 nitrogen, whilst the analysis yielded 70.1 carbon, 4.5 hydrogen, and 17.5 nitrogen, the difference in the numbers being ascribed by Laurent and Gerhardt to a trace of turpentine-oil with which the substance subjected to analysis was contaminated. Azoxybenzide appears to form with bromine a substitution-product corresponding to nitro-azoxybenzide.—When azobenzide,  $C_{24}H_{10}N_2$ (4), is warmed with fuming nitric acid until an action commences, and is then removed from the source of heat, red needles are found to crystallise out on cooling. These crystals are washed with ordinary nitric acid and then with water, and afterwards boiled with alcohol; the solution thus formed is separated from the residue, and the tabular needles

(1) Laur. and Gerh. C. R. 1849, 420; Compt. Rend. XXIX, 489 (in abstr.); Instit. 1849, 363.

(2) Pogg. Ann. XXXII, 225; Berzelius' Jahresber. XV, 432.

(3) J. Pr. Chem. XXXVI, 98; Berzelius' Jahresber. XXVI, 809.

(4) According to Laurent and Gerhardt, azobenzide cannot be a nitrile, since it distils over unchanged when heated with potassa-lime to  $250^{\circ}$ .

Benzole.

which separate from the solution on cooling are washed with alcohol and ether. The compound obtained in this manner is *nitro-azobenzide*,  $C_{24}H_9(NO_4)N_2$ . It is a pale, orange-yellow, fusible body, less soluble in alcohol than azobenzide, but more soluble than the following compound. If azobenzide is heated with fuming nitric acid for some minutes longer the solution yields on cooling red needles which are obtained in a state of purity by washing with nitric acid, water, and ether, and finally recrystallising from alcohol. This compound is *dinitro-azobenzide*,  $C_{24}H_8(NO_4)_2N_2$ ; it fuses in the warmth to a blood-red liquid which on cooling crystallises in needles. Dinitro-azobenzide yields a base when boiled with alcohol and sulphide of ammonium. In preparing this base the ebullition is continued until a portion of the alcohol is expelled, when water is added and, finally, a slight excess of hydrochloric acid; after filtration the base is precipitated whilst warm by ammonia, and purified by recrystallisation from ether. The new base, which is termed *diphenine*, possesses a yellow colour and the composition  $C_{24}H_{12}N_4$ . Nitric and hydrochloric acid dissolve it with a red colour; the latter solution yields, with bichloride of platinum, a dark-crimson precipitate, for which Laurent and Gerhardt adduce the formula  $C_{24}H_{12}N_4 \cdot 2HCl \cdot 2PtCl_2$ .—They append to this investigation some theoretical considerations, from which we may adduce the following conclusions. When the hydrogen of a body derived from a carbohydrogen is replaced by N,  $NO_2$ , or  $NO$ , the compound which is formed is neutral, like the carbohydrogen itself; when the hydrogen of such a body is replaced by  $NH_2$ , the new compound is a base; and, finally, when a carbohydrogen assumes oxygen, without any substitution taking place, the compound which is formed is an acid.

**Mesitylene, or Mesitolole.**—Kane, who first investigated the compound formed by the action of 1 vol. of concentrated sulphuric acid upon 2 vols. of acetone, found it to have the composition  $C_6H_4$ , and the boiling-point  $135^\circ$ . The determination of the density of the vapour of mesitolole induced Cahours to assign to it the formula  $C_{12}H_8$ , and in accordance with this assumption the substitution-products of this carbohydrogen, known up to 1849, were expressed by the formulæ  $C_{12}H_6Cl_2$ ;  $C_{12}H_6Br_2$ ; and  $C_{12}H_6(NO_4)_2$ . The boiling-point of mesitolole, however, does not agree with the formula  $C_{12}H_8$ ; since benzole  $C_{12}H_6$  boils at  $80^\circ$ , and a larger proportion of hydrogen generally induces a depression of the boiling-point. A. W. Hofmann(1) has found the boiling-point of mesitolole, purified as far as possible by repeated rectification, to lie between  $155^\circ$  and  $160^\circ$ . By his investigations, which were undertaken with the view of determining the equivalent of mesitolole by studying its

(1) Chem. Soc. Qu. J. II, 104; Ann. Ch. Pharm. LXXI, 121; Compt. Rend. XXVIII, 130; Instit. 1849, 25; J. Pharm. [3] XVI, 310.

products of decomposition, he found the composition of the crystalline body, produced by the action of bromine, to be expressed by  $C_{12}H_6Br_2$ , as had previously been shown by Cahours; moreover, he found the product of decomposition, produced by a mixture of fuming nitric and sulphuric acid, or by fuming nitric acid alone, to have the composition  $C_{12}H_6(NO_4)_2$ , as had likewise been pointed out by Cahours(1). This latter compound may readily be obtained in a state of purity by recrystallisation from acetone. The action, however, of more dilute nitric acid upon mesitolole, is somewhat different. By repeated distillation with moderately strong nitric acid mesitolole was converted into a crystalline mass, consisting of delicate needles which, when washed with water, and recrystallised from alcohol, exhibited a composition most simply expressed by the formula  $C_{18}H_{10}(NO_4)_2$ , which was confirmed by the conversion of this body into *nitromesidine* (comp. p. 277). This compound is accordingly to be termed *dinitromesitolole*, and mesitolole itself to be expressed by the formula  $C_{18}H_{13}$ ; and hence the previously known substitution-compounds are to be considered as *trinitromesitolole*  $C_{18}H_9(NO_4)_3$ , *trichloromesitolole*  $C_{18}H_9Cl_3$ , and *tribromomesitolole*  $C_{18}H_9Br_3$ .—According to the formula  $C_{18}H_{13}$ , mesitolole is isomeric with cumole, a fact which is confirmed by the composition of mesitilo-sulphuric acid. Fuming sulphuric acid dissolves mesitolole, and forms a brown liquid, which is blackened by heat, and in which an acid is contained that forms a soluble lead-salt. This salt is very soluble in water and in alcohol, and after treatment of the solution with animal-charcoal, may be obtained crystallised in white needles, which have the composition  $PbO, C_{18}H_{11}S_2O_5$ .

**Carbohydrogens from Schist-oil.**—According to a short note published by Saint-Evre(2), it appears that he has obtained in the fractional distillation of schist-oil (*huile de schiste*), by repeated rectification over fused caustic potassa, and over anhydrous phosphoric acid, the following series of carbohydrogens:

$C_{72}H_{68}$  (or  $C_{72}H_{34}$ ?) with a boiling-point between  $275^\circ$  and  $280^\circ$ ;  
 $C_{56}H_{52}$  (or  $C_{56}H_{26}$ ?) with a boiling-point between  $255^\circ$  and  $260^\circ$ ;  
 $C_{52}H_{48}$  (or  $C_{52}H_{24}$ ?) with a boiling-point between  $215^\circ$  and  $220^\circ$ ;  
 $C_{36}H_{32}$  (or  $C_{36}H_{16}$ ?) with a boiling-point between  $132^\circ$  and  $135^\circ$ .

Saint-Evre has not stated whether, in his formula, he assumes the ratio of carbon to hydrogen as 1 to 6, or as 0.5 to 6. These bodies yield, with fuming nitric acid, liquid nitro-substitution-products, which furnish organic bases when acted upon by sulphide of ammonium.

(1) Annual Report for 1847 and 1848, II, 52.

(2) Compt. Rend. XXIX, 339; Instit. 1849, 306.



Turpen-  
tine-oil.

**Turpentine-oil.**—*Terebic acid*, which is formed on the decomposition of turpentine-oil by nitric acid(1), has been subjected, by Cailliot, to a more accurate investigation, of which, however, only a short abstract(2) has as yet been published. According to this chemist terebic acid, which in the free state has the composition  $C_{14}H_{10}O_8$ , is decomposed by heat into *pyroterebic acid*, and carbonic acid. It forms soluble and crystallisable salts, of the formula  $RO, C_{14}H_9O_7$ . In the preparation of basic salts he obtained an insoluble lead-salt  $2 PbO, C_{14}H_8O_6$ , and other basic salts  $2 RO, C_{14}H_{10}O_8$ , and  $2 RO, C_{14}H_{13}O_{11}$ ; in the former he assumes the presence of a bibasic *diaterebic acid*, and in the latter a bibasic *metaterebic acid*. Protoxide of lead forms, with these acids, compounds, of which two deport themselves as acids. The ether-compounds of terebic acid  $C_{14}H_9O_7, C_nH_{n+1}O$ , form combinations with bases. Terebate of ethyl produces with baryta a compound  $C_{14}H_8O_6, BaO, C_4H_5O$ , which is very readily decomposed.

F. C. Schneider(3) has investigated the volatile products of the oxidation of turpentine-oil by nitric acid, and has proved that volatile acids are formed of the series  $C_nH_nO_4$ . Turpentine-oil was oxidised in a retort by the gradual addition of from five to six times its weight of concentrated nitric acid, heat being applied only at the commencement and at the end of the oxidation. The neck of the retort was considerably lengthened, and kept perfectly cooled; after the action had ceased the residue was homogeneous, and on cooling a brownish-red resinous substance separated, which was somewhat similar to the product obtained by oxidising the distillation-products of fat (p. 235). The greenish-yellow distillate was saturated with carbonate of potassa, and after the nitrate of this base had crystallised out, the mother-liquor was distilled with sulphuric acid. The slightly milky, acid distillate, smelling of acetic acid and rancid butter, was saturated with carbonate of soda, and decomposed by nitrate of silver, a reduction of the oxide of silver being observed to take place particularly on ebullition. The precipitate of the silver-salts thus produced was repeatedly treated with a small quantity of water, and from the solution thus obtained the salts were separated from each other by recrystallisation. By this method the silver-salts of butyric acid, propionic acid, and of acetic acid, together with double-salts containing two of these acids in equal equivalents, were obtained.

Deville(4) has published investigations on hydrate of turpentine-

(1) Comp. Annual Report for 1847 and 1848, II, 47.

(2) Instit. 1849, 353; Phil. Mag. [3] XXXVI, 76.

(3) Wien. Acad. Ber. 1849, Nov. and Dec., 337.

(4) Ann. Ch. Phys. [3] XXVII, 80; Ann. Ch. Pharm. LXXI, 348; J. Pr. Chem. XLVIII, 62 (in abstr.)

oil, or terpin(1), of which an abstract(2) had previously appeared in 1843. We shall adduce from these researches only the following statements. The compound  $C_{20}H_{22}O_6$ , which separates from turpentine-oil by digestion with alcohol and nitric acid, is merely isomeric, but, as the crystalline form shows, not identical with the body which is frequently deposited from turpentine-oil, when these substances have not been added. The compound  $C_{20}H_{20}O_4$ , which possesses a vapour-density of 6.26, and is formed by heating or placing the former *in vacuo*, is again converted, by exposure to a moist atmosphere, into  $C_{20}H_{22}O_6$ . These compounds are converted by hydrochloric acid into  $C_{20}H_{18}Cl_2$ , from which an oil, having the properties of lemon-oil, is separated by potassium. By the action of anhydrous phosphoric acid, turpentine-oil ( $C_{20}H_{16}$ ),  $C_{20}H_{20}O_4$ , and  $C_{20}H_{22}O_6$ , are decomposed into water, terebene  $C_{20}H_{16}$ , which is more volatile, and colophene ( $C_{40}H_{32}$ ), which is less volatile.

Turpentine-oil.

**Elemi-oil.**—Deville has, moreover, published in detail the results of some investigations of other volatile oils, part of which had been previously made known.—Elemi-oil, of which upwards of 13 per cent was obtained from 100 parts of good resin, possesses, when pure, a sp. gr. of 0.849 at  $11^\circ$ , and a constant boiling-point of  $174^\circ$ , at a barometric pressure of 755<sup>mm</sup>, and an index of refraction of 1.4719 at  $14^\circ$ ; the composition, as Stenhouse(3) had previously proved, was found to be  $C_{20}H_{16}$ , and the density of its vapour observed to be 4.84. It forms with hydrochloric acid two compounds of the same composition  $C_{20}H_{18}Cl_2$ , one of which is solid and crystallisable, and the other fluid(4).

**Oil from the Resin of *Bursera Gummiifera*.**—The resin of *Bursera gummiifera* yields about 4.7 per cent of oil, which is termed *essence de gomart*, or gomart-oil. The oil of this resin was purified by leaving it in contact with solid potassa, treating it with potassium, and finally rectifying it. The oil thus purified is colourless, and smells like the oil of turpentine, with which it is also analogous in composition ( $C_{20}H_{16}$ ). It has likewise the same density of vapour, which was found by observation to be 4.70. By the action of hydrochloric acid two products are formed. These substances, when exposed to a very low degree of cold, and pressed between bibulous-paper, yield white silky needles  $C_{20}H_{18}Cl_2$ , which are isomeric with the compound derived from lemon-oil.

(1) Annual Report for 1847 and 1848, II, 45.

(2) Rev. Scientif. Industr. XV, 66; Instit. 1843, 89; Berzelius' Jahresber. XXIV, 477.

(3) Ann. Ch. Pharm. XXXV, 304; Berzelius' Jahresber. XXI, 351.

(4) Regarding Deville's earlier communication on elemi-oil, comp. Compt. Rend. XII, 184; Instit. 1841, 22; Berzelius' Jahresber. XXII, 296.

Action of  
potassa  
upon  
balsams.

**Action of Potassa upon Balsams.**—Scharling(1) has published the following statements regarding the action of potassa upon balsams. One part of Peruvian balsam left in contact for 24 hours with from two to three parts of potassa-solution of 1·3 sp. gr., and then distilled, yielded a distillate consisting of water and two oils, one lighter and the other heavier than water. The heavier oil when dried and rectified, has a sp. gr. of 1·03, and a boiling-point of 205°; when first prepared it smells very slightly, but after some time it acquires an odour of cinnamic ether; it remains liquid at -15°. The lighter oil boils at about 180°, the greater part thereof solidifying at -15°. Both liquids yield with hydrate of potassa and bisulphide of carbon a solid mass, which exhibits with salts of copper and lead the reactions of xanthic acid. The oily liquids which pass over when Peruvian balsam is distilled alone, or with solutions of salt or chloride of zinc, do not exhibit this deportment with hydrate of potassa and bisulphide of carbon; the distillate, however, which is prepared from a mixture of carbonate of soda, and the residue left in the treatment of Peruvian balsam with a solution of carbonate of soda, does exhibit this character. Since the recognised ethers—for instance, acetic ether—when treated with hydrate of potassa and bisulphide of carbon, yield a mass which shows the reactions of xanthic acid, we may conclude that cinnamic ether certainly does not pre-exist in Peruvian balsam; but that it is formed by the action of strong bases on it.—On distilling liquid storax with potassa, an oil is obtained which agrees with Simon's styracone (comp. below.) This oil likewise exhibits the above-mentioned deportment with potassa and bisulphide of carbon, and is also to be regarded as a compound ether: the distillate, however, from copaiva, which has been previously treated with potassa, does not show the same deportment. Turpentine-oil yields, with moderately dry hydrate of potassa and bisulphide of carbon, a mass whose reactions are very similar to those of xanthic acid.

**Storax.**—In 1827 Bonastre(2) had discovered in liquid storax a neutral crystallisable substance which he called *styracin*. E. Simon(3), in 1839, found therein a volatile oil (*styrole*), styracon, cinnamic acid, and several resins, and he moreover observed that styracon was converted by caustic potassa into cinnamic acid and a difficultly volatile oil which has received the name of *styracone*. At that time R. F. Marchand found the composition of styracon to be  $C_{24}H_{11}O_2$ . Investigations on this subject have been published in 1849 by E. Kopp and by Toel. The former of these chemists has published only his results.

(1) Chem. Gaz. 1849, 417.

(2) J. Pharm. [2] XIII, 151; Berzelius' Jahresber. VIII, 261.

(3) Ann. Ch. Pharm. XXXI, 265; Berzelius' Jahresber. XX, 406.

According to E. Kopp(1) styrole is identical with cinnamin or cinnamole ( $C_{16}H_8$ ) as obtained in the distillation of cinnamic acid with baryta. He states that styracin may be obtained in the amorphous and in the crystallised condition; in the former state it is identical with Fremy's(2) cinnamëin, and in the latter with his metacinnamëin; its composition is  $C_{36}H_{18}O_4$ . Styracone he states to be identical with Fremy's peruvine(3) and to be expressed by the formula  $C_{18}H_{12}O_2$ . The decomposition of styracin by caustic potassa into cinnamic acid and styracone he expresses by the equation  $C_{36}H_{18}O_4 + 2 HO = C_{18}H_8O_4 + C_{18}H_{12}O_2$ . Hence styracin comports itself in an analogous manner to fats which are decomposed by alkalis into acids and glycerin.—For obtaining the different constituents of storax, Kopp recommends to distil it with from 5 to 6 times its weight of water, the styrole being thus volatilised with the water. The cinnamic acid is obtained from the residue of the distillation by frequent exhaustion with a dilute solution of carbonate of soda; the aqueous extract is concentrated and decomposed by an excess of boiling hydrochloric acid, when the cinnamic acid separates, but is contaminated with a resinous substance; by careful distillation nearly pure cinnamic acid passes over at first, but at a subsequent stage of the operation it is contaminated with empyreumatic oils which may be removed by filtering the hot aqueous solution through a filter placed in a hot-water funnel. Kopp recommends this method for the preparation of cinnamic acid. From the residue remaining after exhaustion with carbonate of soda, a yellow oily liquid is obtained by submitting it to pressure. This liquid is filtered whilst warm, when it soon solidifies to a mass of styracin; the latter is treated with 10 times its weight of alcohol of  $50^\circ$ , and by exposing the solution to a very low temperature the compound crystallises in needles of perfect purity. It fuses at  $38^\circ$ , and is thereby frequently transformed into the amorphous variety. The resinous residue from which the styracin has been expressed is conveniently distilled with caustic potassa or soda in order to prepare cinnamic acid and styracone. The latter is a colourless liquid, boiling at  $254^\circ$ ; it solidifies at a low temperature, but liquifies again at  $8^\circ$ .

Toel's(4) experiments are not in accordance with the statements of E. Kopp. This chemist prepared styracin by distilling storax with a solution of carbonate of soda, extracting the cinnamate of soda

(1) Instit. 1849, 182; Laur. and Gerh. C. R. 1850, 140.

(2) Ann. Ch. Phys. [2] LX, 180; Ann. Ch. Pharm. XXX, 324; Berzelius' Jahresber. XX, 396, 404.

(3) Berzelius' Jahresber. XX, 400.

(4) Ann. Ch. Pharm. LXX, 1; Arch. Pharm. [2] LVIII, 195; Instit. 1849, 157; J. Pharm. [3] XVI, 39; Laur. and Gerh. C. R. 1849, 414.

Storax.

from the residue, and macerating the remaining resinous mass, previously washed and dried, with cold alcohol, which left behind the chief part of the styracin only slightly coloured. It was then repeatedly recrystallised from a mixture of alcohol and ether. When thus prepared it forms long prisms united in feathery groups: it is odourless and tasteless, is insoluble in water, slightly soluble in cold alcohol, and readily soluble in ether. At  $44^{\circ}$  it fuses, and remains for a long time after cooling amorphous, but subsequently solidifies in concentrically-grouped warty crystals; in contact, however, with a pointed body it crystallises instantly at the point of contact. Toel deduces from his analysis the formula  $C_{60}H_{28}O_6(1)$ . By distilling with an excess of a strong potassa-solution cinnamic acid was formed; the oil, however, which Simon (page 310) terms styracone, was not obtained amongst the volatile products of the decomposition, but merely a crystallisable body, which Toel terms *styrone*. The milky liquid, when allowed to remain at rest, became clear, and filled with delicate crystalline needles of styracone. When well cooled, styracone condensed in a crystalline form, even in the condensing tube. From the water out of which styracone has crystallised a farther quantity may be obtained either by saturating with salt or by agitating it with ether. Styracone forms long silky needles, and possesses an agreeable odour resembling that of hyacinths; it fuses at  $33^{\circ}$ , sublimes without change at a higher temperature, is moderately soluble in water, and readily soluble in alcohol, ether, and in volatile and fatty oils. On cooling the hot aqueous solution, droplets of oil separate which solidify to crystalline needles. When distilled with binoxide of manganese and dilute sulphuric acid it yields oil of bitter almonds in a similar manner to styracin. From his analyses Toel deduces for styracone the formula  $C_{42}H_{23}O_5$ . He considers styracin,  $C_{60}H_{28}O_6$ , as a body analogous to the fats, which is decomposed by the alkalis into cinnamic acid,  $C_{18}H_7O_3$ , in the hypothetical anhydrous condition, and an hypothetical *oxide of styryle*,  $C_{42}H_{21}O_3$ , which yields styracone by the assimilation of 2 equivs. of HO.—Dry chlorine transforms styracin into a viscid mass, a slight development of heat being perceptible at the same time. In order to complete the action the mass must be heated to  $100^{\circ}$ . The product, *chlorostyracin*, is yellow, viscid and adhesive, insoluble in water, and separates in the amorphous condition from its solutions in hot alcohol or ether. Toel states the composition to be  $C_{60}H_{21}Cl_7O_6$ . If an alcoholic solution of chlorostyracin is mixed with excess of an alcoholic solution of potassa the whole solidifies after some time to a crystal-

(1) R. F. Marchand (Ann. Ch. Pharm. LXXI, 357; J. Pr. Chem. XLVII, 184) has stated that his former analyses, which led to the formula  $C_{21}H_{11}O_2$  (p. 310), agree also with Toel's formula, when calculated according to the new equivalent of carbon, &c.

line magma of chloride of potassium and chlorocinnamate of potassa; the magma is washed with spirit of wine, pressed out, dissolved in a small quantity of boiling water, and the solution saturated with hydrochloric acid, when on cooling long needles of *chlorocinnamic acid* separate, and may be purified by recrystallisation. It forms long lustrous needles which are odourless, fuse at  $132^{\circ}$ , and sublime unchanged at a higher temperature; they are slightly soluble in cold water, but to a greater extent in hot water, and readily soluble in alcohol and in ether. The excess of acid in the saturated boiling aqueous solution fuses to an oil. The composition of the acid is  $C_{18}H_6ClO_3$ , HO, and that of its silver-salt  $AgO$ ,  $C_{18}H_6ClO_3$ . The latter was prepared by mutual decomposition; it crystallised from hot solutions in needles which became discoloured in the light. The baryta-salt crystallises from the hot aqueous solution in plates which still contain 1 equiv. of water of crystallisation. In the decomposition of chlorostyracin by potassa there is formed, besides chlorocinnamic acid, a chlorinated oil which remains dissolved in the alcohol. If the greater part of the alcohol is carefully distilled off, and water added to the residue, the oil, which possesses a brown colour, falls to the bottom. When distilled with water the oil passes over with it nearly colourless, but becomes rapidly brown again by exposure to the air. It possesses a great similarity to the oil which Stenhouse(1) obtained by the action of chlorine upon cinnamic acid.

Strecker(2) has pointed out that the formula  $C_{18}H_{10}O_2$  for styrene,  $C_{36}H_{16}O_4$  for styracin, and  $C_{36}H_{12}Cl_4O_4$  for chlorostyracin, are reconcilable with Toel's analyses. Accordingly styrene would stand to cinnamic acid in the same relation as wood-spirit to formic acid, alcohol to acetic acid, &c.; by the action of alkalies and the assimilation of 2 HO, styracin would be decomposed into styrene and cinnamic acid.

Regarding Scharling's statements, compare page 309.

**New Variety of Copaiva-Balsam.**—The hitherto known varieties of *balsamum copaivæ* yield when mixed in proper proportions with potassa- or ammonia-solution a more or less clear solution; from the ammonia-solution, after some time, crystals of copaiate of ammonia are deposited. Posselt(3) has investigated a variety of this balsam which, although unadulterated, does not exhibit this reaction; it smells and tastes like the ordinary kinds of copaiva, but is thinner, of a brighter yellow colour, and of 0.94 sp. gr.; it forms with potassa or ammonia, in all proportions, an opaque mixture from which the balsam again speedily separates. It dissolves but imper-

(1) Phil. Mag. [3] XXVII, 366; Berzelius' Jahresber. XXVI, 454.

(2) Ann. Ch. Pharm. LXX, 10.

(3) Ann. Ch. Pharm. LXXIX, 67.

New  
variety of  
copaiva-  
balsam.

fectly in alcohol, and contains 82 per cent of oil and 18 per cent of resin.—The oil obtained by distillation with water, rectified in a similar manner, and dried over chloride of calcium, is colourless and of thickish consistence; it is readily soluble in ether, but only slightly soluble in absolute alcohol. It possesses a strong and pure copaiva odour and burning taste, and a sp. gr. of 0.91; it boils at 252° with decomposition and rise of the boiling-point. The oil absorbs dry hydrochloric acid-gas with formation of a brown liquid which fumes in contact with the air and from which no crystallisable compound could be separated. The composition of this oil, which Posselt terms *para-copaiva-oil*, is expressed by the formula  $C_{10}H_8$ ; with concentrated nitric acid it explodes, but when boiled with the diluted acid it yields a resin, volatile acids and a small quantity of a crystallisable acid which remains behind in colourless plates. It dissolves iodine without giving rise to a powerful reaction, and under the influence of chlorine becomes yellow and viscid.—In the residue of the distillation of the new copaiva-balsam with water there remains a mixture of two indifferent resins; the one which is soluble in alcohol is of a bright-yellow colour, non-crystallisable, and contains on the average 60.0 per cent carbon, 8.3 hydrogen, and 31.7 oxygen; that which is insoluble in alcohol, but dissolves readily in ether or in petroleum, is likewise bright-yellow and non-crystallisable; the mean numbers on analysis were 81.9 per cent carbon, 10.5 hydrogen, and 7.6 oxygen. The two resins are insoluble in alkalis.

**Guaiacum-Resin.**—Van den Broek(1) has published an investigation regarding the blue colouration which is caused in an alcoholic tincture of guaiacum by fresh potatoes; he has arrived at the conclusion that the blue colour is produced by the conjoint action of atmospheric air and the albuminous constituents of the potatoes.

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**Colouring Principles of Madder-Root.**—In the Annual Report for 1847-8, II, 77 we reported upon the investigations of Schunck regarding the colouring principles of madder-root. We then alluded to various papers published about the same time as those which formed the principal subject of our report, containing some statements which differed in certain particulars from those made in the paper abstracted by us (see the annotations to the Annual Report for 1847-8, II, p. 77 and following pages). More recent papers published by Schunck(2) show that he considers the statements contained in the text of the last Report, II, 77 and 78, as correct, and

(1) Scheikundige Onderzoekingen, V, 3. Stuk, 210.

(2) Report of the British Assoc. for 1848; Reports of Researches in Science, 57; Phil. Mag. [3] XXXV, 204; J. Pr. Chem. XLVIII, 299.

fully established by his more complete investigations, and that the statements appended in our notes are erroneous.

**Wongshy.**—W. Stein(1) has investigated a new colouring principle imported from Batavia under the name of *wongshy*, and consisting of the seed-capsule of a species of gentian. It imparts to water and spirit of wine, according to the state of concentration, a yellow or fiery-red colour, and to ether, which at the same time extracts a brown oil, a colour varying from pale-yellow to brownish-yellow. The aqueous extract likewise contains pectin and sugar. The reactions of the liquid, after having been freed from pectin by means of alcohol, have been minutely studied by the author. It yields with baryta- and lime-water yellow precipitates, from which acids separate the colouring-matter of a vermillion colour; when thus prepared it is insoluble in water, and but slightly soluble in spirit of wine and in ether. Regarding the other details which are given by Stein, we must refer to the original memoir.

**Purree, or Jaune Indien.**—In the colouring substance occurring in commerce under the name of purree or jaune indien an acid is contained, in combination with magnesia. This acid is termed by Erdmann(2) euxanthic acid, and by Stenhouse(3) purric acid; when heated it yields Erdmann's euxanthone and Stenhouse's purrenone or purrone. This acid, as well as the latter product, yield by treatment with chlorine, bromine, sulphuric acid and nitric acid products of decomposition which have been accurately investigated, especially by Erdmann. Laurent(4) has proposed for these compounds and their derivatives other formulæ which explain the decompositions more clearly, and agree with his own and Gerhardt's views regarding the composition of chemical compounds. These new formulæ, which we have translated into the notation adopted in this Report, are based upon Laurent's own analyses of euxanthic acid and of euxanthone, and upon the recalculation of the analyses made by Erdmann and Stenhouse. In accordance with a conjecture made by Gerhardt at an earlier period, Laurent states that dried euxanthic acid is expressed by the formula  $C_{42}H_{18}O_{22}$ , the acid in the neutral salts by  $C_{42}H_{17}O_{21}$ , and euxanthone by  $C_{40}H_{12}O_{12}$ . For the two former Erdmann had adopted the formula  $C_{40}H_{16}O_{21}$ , and for the latter  $C_{13}H_4O_4$ . The formation of euxanthone is expressed by the equation  $C_{42}H_{18}O_{22} = C_{40}H_{12}O_{12} + 2CO_2 + 6HO$ . Kokkinonic acid he believes to be  $C_{12}H_3(NO_4)O_6$ , and to be derived from an acid of the composition

(1) From Hülse and Stöckhardt's Polytechn. Centralbl. 1849, 19. Lieferung, in J. Pr. Chem. XLVIII, 329; Chem. Gaz. 1850, 73.

(2) J. Pr. Chem. XXXIII, 190; XXXVII, 385; Berzelius' Jahresber. XXV, 680 XXVII, 306.

(3) Ann. Ch. Pharm. LI, 423; Berzelius' Jahresber. XXV, 680.

(4) Laur. and Gerh. C. R. 1849, 377.



Purree, or  
jaune  
indien.

$C_{12}H_4O_6$ ; porphyric acid to have the composition  $C_{26}H_3(NO_4)_3O_8$ , and to be formed from an acid  $C_{26}H_6O_8$ , to which he assigns the name porphyric acid. Oxyporphyrin acid appears to the author not to differ from Erdmann's porphyric acid; the formula of oxyporic acid (styphnic acid) he proposes to write  $C_{12}H_3(NO_4)_3O_6$ , and regards this acid as being derived from the compound  $C_{12}H_6O_4$ . He moreover adduces formulæ which are stated to render the decomposition of cuxanthic acid and of cuxanthone by nitric acid, and the formation of the above-mentioned nitrogenous acids perfectly intelligible: according to these formulæ, however, the compound termed by Laurent porphyric acid now becomes all of a sudden  $C_{26}H_8O_8$ .

**Colouring Principles of Asparagus Berries.**—Kerndt(1) has found in the berries of asparagus a yellow (*chrysoïdin*) and a red colouring matter (*eöidin*). The latter of these principles is by no means identical with the colouring matter of annatto, as had been asserted by Braconnot(2). For pure chrysoïdin, Kerndt gives the formula  $C_{24}H_{22}O_8$ , for eöidin  $C_{24}H_{22}O_3$ , and for the colouring principle of annatto  $C_{16}H_{13}O_2$ . If the latter formula were multiplied by  $\frac{3}{2}$ , it would closely approximate to the formula adopted by Kerndt for eöidin.

**Colouring Principles of Lichens.**—Stenhouse(3) has continued his earlier researches(4) regarding the colouring matters of lichens.

**Investigation of *Gyrophora Pustulata*.**—*Gyrophora pustulata*, termed in Canada *tripe de roche*, is employed in the preparation of archill, although the proportion of colouring matter it contains scarcely amounts to  $\frac{1}{2}$  of that which is found in *Rocella Montagnei*(5). The varieties submitted to investigation came from Norway. The colouring principle was extracted by maceration with milk of lime, and was precipitated from the extract by hydrochloric acid as a gelatinous, reddish-brown precipitate. The colouring matter was washed with cold water, dried at a gentle heat, and, in order to remove a green, resinous substance, heated nearly to ebullition with dilute spirit of wine. The insoluble portion which remained was heated, but not to ebullition, with a large quantity of animal charcoal and strong alcohol, whereby a brown substance resembling humus remained undissolved. The colouring principle was deposited from the filtrate in small verrucose crystals, which were obtained pure by repeated recrystallisation from spirit of wine, to which animal charcoal was added. This compound is termed by Stenhouse *gyrophoric acid*. When pure, it forms small soft, colourless, odourless,

(1) Dissertatio de fructibus asparagi et bixæ orellanæ; Lipsiæ, 1849.

(2) Annual Report for 1847 and 1848, II, 93.

(3) Ann. Ch. Pharm. LXX, 218; Chem. Gaz. 1849, 265; Phil. Mag. [3] XXXIV, 463; Instit. 1849, 268.

(4) Annual Report for 1847 and 1848, II, 65.

(5) Annual Report for 1847 and 1848, II, 69.

and tasteless crystals, which are almost insoluble in cold and in boiling water, and difficultly soluble in alcohol and in ether. The solution produces no effect upon litmus; but, on the slightest addition of an alkali, it gives an alkaline reaction. The composition of the acid, dried *in vacuo*, is stated by Stenhouse to be  $C_{36}H_{18}O_{15}$ . On boiling this acid with an excess of an alkali or alkaline earth, it is converted into orcin, with formation of carbonic acid; but when boiled with a small quantity of alkali, it forms, like orsellic acid(1), an intermediate acid, which exhibits an acid reaction, and crystallises in a different form. Gyrophoric acid too produces, with solution of chloride of lime, a beautiful red colour, which however disappears less rapidly than that which is given by orsellic and other analogous acids. Gyrophoric acid is not soluble even in a large excess of a cold aqueous solution of ammonia; but when boiled with an alcoholic solution of ammonia, it dissolves with decomposition and formation of an intermediate acid. If exposed to the atmosphere with an excess of ammonia, it is slowly transformed, like the other acids of lichens, into a purplish, red-colouring principle. On boiling gyrophoric acid several hours with concentrated alcohol, it forms, in addition to a small quantity of orcin and a resinous matter, an ethyl-compound, which is readily soluble in hot water. It is purified in the same manner as the analogous ethers(2) obtained from orsellic and erythric acids, to which in its other properties it is perfectly similar; its composition is  $C_4H_5O$ ,  $C_{36}H_{18}O_{15}$ . A corresponding methyl-compound may be prepared by boiling the acid with pyroxilic spirit. Gyrophoric acid dissolves readily in baryta-water, and is again precipitated from its solution by acids, unchanged in its properties. If carbonic acid is passed into the solution, and the salt of the organic acid is extracted from the dried precipitate by hot alcohol, the alcoholic solution is found to deposit small white crystals of a baryta-compound, which contain an acid differing from gyrophoric acid. The precipitate produced on mixing alcoholic solutions of gyrophoric acid and basic acetate of lead, has a variable composition. Stenhouse did not succeed in preparing any salt of this acid in constant atomic proportions.

**Investigation of *Lecanora Tartarea*.**—A specimen of Norwegian *Lecanora tartarea*, which is likewise employed in the preparation of archill(3), was submitted to investigation. The colouring principle was prepared in the same manner as that of the preceding lichen. The study of its composition and properties, as well as the investigation of the ethyl-compound, enabled Stenhouse to recognise it as

(1) Annual Report for 1847 and 1848, II, 65.

(2) Annual Report for 1847 and 1848, II, 68.

(3) Regarding the proportion of colouring matter, comp. Annual Report for 1847 and 1848, II, 69.

Investiga-  
tion of  
*Lecanora*  
*tartarea*.

identical with gyrophoric acid, obtained from *Gyrophora pustulata*.—He opposes the view of Schunck(1), that the ethyl-compounds, which are formed by the different acids obtained from lichens, are all identical, and are actually lecanoric ether. However, it must be added, that the composition of the compound termed by Stenhouse gyrophorate of ethyl agrees very closely with that assigned to lecanoric ether.

**Erythro-mannite.**—By boiling picro-erythrin or erythric acid with an excess of lime- or baryta-water, Stenhouse had obtained a beautiful crystallisable body, which he termed pseudo-orcin or erythroglucin, and considered as  $C_{10}H_{13}O_{10}$ (2). Schunck proposed for this compound the term eryglucin, and the formula  $C_{22}H_{26}O_{22}$ (3). Stenhouse now adopts for this compound the name erythro-mannite, and the formula  $C_{11}H_{14}O_{11}$ . By treatment with fuming nitric acid, he has succeeded in preparing therefrom an explosive compound. It is obtained by adding erythro-mannite, in small portions at a time, to fuming nitric acid, which is kept perfectly cold. After complete solution has been effected, a quantity of sulphuric acid, equal in weight to the nitric acid, or somewhat more, is added; the crystalline magma, which is slowly formed, is placed in a funnel, stopped with asbestos; and after the acid has ceased to drop, it is washed with cold water, pressed out, and recrystallised from boiling alcohol. By dissolving the erythro-mannite in a mixture of fuming nitric and sulphuric acid, and subsequently adding water, this compound could not be formed. By the former process, a neutral substance is obtained in large foliaceous crystals. This compound is *nitro-erythro-mannite*, which is termed by Stenhouse nitrate of erythro-mannite; it fuses at  $61^{\circ}$ , and on cooling becomes a crystalline mass. When more strongly heated, it inflames and burns rapidly; and when struck with a hammer, it detonates. It therefore exhibits a deportment perfectly analogous to nitro-mannite (nitrate of mannite). This analogy, according to Stenhouse, is likewise perceived in the composition of the two compounds: he has deduced from his analyses the following formulæ:

Mannite . . . . .	$C_{12}H_{14}O_{12}$	Erythro-mannite . . . . .	$C_{11}H_{14}O_{11}$
Nitrate of mannite . . . . .	$C_{12}H_9O_7 + 5 NO_5$	Nitrate of erythro-mannite . . . . .	$C_{11}H_9O_6 + 5 NO_5$
(or Nitro-mannite . . . . .)	$C_{12}H_9(NO_4)_5O_{12}$	(or Nitro-erythro-mannite . . . . .)	$C_{11}H_9(NO_4)_5O_{11}$

The formula of nitro-mannite agrees with that proposed by Domonte and Menard (comp. p. 322, and following pages).

**Litmus.**—According to Pereira(4), the Dutch or cake-litmus is mixed with indigo. This kind of litmus contains a peculiar blue

(1) Annual Report for 1847 and 1848, II, 75.

(2) Annual Report for 1847 and 1848, II, 68.

(3) Annual Report for 1847 and 1848, II, 75.

(4) Pharm. J. Trans. IX, 12.

substance, derived from the lichens; indigo; organic remains of lichens; an organic ammonia-salt, which is volatilised by heat as carbonate; and earths.

Products  
of the  
decompo-  
sition of  
indigo.

**Products of the Decomposition of Indigo.**—Laurent(1) has reinvestigated some of the decomposition-products of indigo, which he had studied at a former period(2), and has now arrived at somewhat different results.—The composition of *indin*, which he formerly regarded as  $C_{16}H_6NO_2$ , he now finds to be  $C_{32}H_{10}N_2O_4$ . If indin is moistened with a little alcohol, slightly warmed, and mixed with a hot concentrated solution of potassa in alcohol, it forms a black solution, from which small black crystals are soon deposited. Laurent finds that these crystals contain from 11·5 to 12 per cent of potassium; he adopts the formula  $KO, C_{32}H_9N_2O_3$ , which requires 13 per cent of potassium. He remarks that the compound is difficult to obtain in a state of purity, and that its analysis serves merely to decide whether indin contains 16 or 32 eqivs. of carbon.—Indin is converted by nitric acid into *nitrindin*, to which Laurent formerly assigned the composition  $C_{16}H_4N_2O_7$ , but now finds it to be represented by the formula  $C_{32}H_8(NO_4)_2N_2O_4$ , according to which it is a substitution-product of indin.—By heating either isathyde, mono- or disulphuretted isathyde (sulphasathyde or sulphesathyde), or indin, with an alcoholic solution of potassa, *hydrindin* is produced. The liquid, which is at first black, soon becomes somewhat yellowish, and yields on cooling small, yellow, lustrous crystals of hydrindin-potassa. Laurent formerly considered this compound as hydrindin, but he now finds that, in contact with water, it is gradually decomposed, whereby the hydrindin remains behind as a white powder. If the potassa-compound is dissolved in boiling alcohol, with which a little potassa is mixed, and water is gradually added, the liquid solidifies on cooling to a magma of crystalline needles, that have not been more minutely investigated, but which are converted, by a larger addition of water, into a white powder of hydrindin. Laurent has found for the potassa-compound the composition  $KO, C_{64}H_{27}N_4O_{15}$ ; it loses by drying 9 per cent of water. Accordingly Laurent considers the formula of the anhydrous potassa-compound to be  $C_{64}H_{21}N_4O_9$ , and that of hydrindin  $C_{64}H_{22}N_4O_{10}$ . Former analyses gave 26 eqivs., and more recent experiments from 25 to 26 eqivs. of hydrogen to 64 eqivs. of carbon; but, bearing in mind the decomposition of hydrindin, Laurent is inclined to believe that it contains only 22 eqivs. of hydrogen.—The liquid obtained in the preparation of hydrindin

(1) Laur. and Gerh. C. R. 1849, 196; J. Pr. Chem. XLVII, 159; Ann. Ch. Pharm. LXXII, 282 (in abstr.)

(2) Ann. Ch. Phys. [3] III, 373, 462; Ann. Ch. Pharm. XLVIII, 281; Berzelius' Jahresber. XXII, 412.

Products  
of the  
decompo-  
sition of  
indigo.

from disulphuretted isathyde or indin with potassa, from which hydrindin has been separated, yields on addition of an acid a light, yellowish, flocky precipitate, which is a mixture of hydrindin, sulphur, sometimes a portion of indin, and a new compound which has received the name of *flavindin*. The latter is formed in larger quantity, when the ebullition with potassa is continued somewhat longer; it may be extracted from the mixture by water, to which a few drops of ammonia are added, and precipitated from this solution by hydrochloric acid. It is somewhat yellow, slightly soluble in boiling alcohol, and crystallises from this solution in microscopic needles, which are united in star-shaped groups. It yielded on analysis 72.5 per cent of carbon and 3.8 hydrogen, and, according to Laurent, is polymeric, both with indin and indigo. Flavindin is transformed by heat into a white sublimable body. When dissolved in ammonia, it gives, with nitrate of silver, a yellow precipitate of *flavindate* of silver, which, according to Laurent, is represented by the formula  $\text{AgO}, \text{C}_{16}\text{H}_6\text{NO}_3$ . The compounds which Erdmann obtained by treating chlorisathyde and dichlorisathyde with potassa, and termed *b* chlorisatic acid and *b* dichlorisatic acid, are now considered by Laurent to be mono- and dichlorinated flavindic acid.—Laurent recommends the preparation of *isathyde* by heating pulverised isatin in a flask, with a large quantity of water, a little sulphuric acid, and pure sheet zinc. Isatin, as it dissolves in the liquid, seizes the nascent hydrogen, and is transformed into isathyde, which is precipitated as a crystalline powder. This is then washed, and boiled out with alcohol, in order to remove the last traces of isatin.

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**Sugar.**—Sthamer(1) has pointed out that the crystals of sugar occurring in the flowers of *Rhododendron ponticum* consist of pure cane-sugar.

As a completion of a former memoir(2) regarding the various kinds of sugar, Dubrunfaut(3) has published the following statements:—If cane-sugar is acted upon by weak acids or ferments, the product is found to contain two varieties of sugar mixed or combined in equal equivalents: these consist of ordinary crystallisable grape-sugar (*glucose*, of the formula  $\text{C}_{12}\text{H}_{12}\text{O}_{12}$ , when dried at  $100^\circ$ ) and an uncrystallisable sugar. The latter, when dried at  $100^\circ$ , has likewise the composition  $\text{C}_{12}\text{H}_{12}\text{O}_{12}$ , and yields by fermentation the same quantity of alcohol and carbonic acid as is given by grape-sugar. The power of rotating the plane of polarisation towards the left, possessed

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(1) Arch. Pharm. [2] LIX, 151.

(2) Comp. Annual Report for 1847 and 1848, II, 96.

(3) Compt. Rend. XXIX, 51; Instit. 1849, 242.

by the uncrystallisable sugar, is four times greater than that of the sugar which has been acted upon, at the same temperature and under similar circumstances, and suffers by the elevation of the temperature from  $14^{\circ}$  to  $52^{\circ}$  a diminution of  $\frac{2}{37}$ . It forms with lime a soluble basic compound, analogous to that which is formed by grape-sugar, and like the latter readily undergoes decomposition, absorbing oxygen from the atmosphere with formation of a new product which has not been more minutely investigated; it moreover produces with lime a slightly soluble compound, crystallising in microscopic needles, which contains at least 6 equivs. of lime to 1 equiv. of sugar, and is decomposed when exposed to the atmosphere. When cane-sugar is heated with water or with dilute acids it undergoes in the first place this peculiar change, and then the uncrystallisable sugar only, and not the grape-sugar, is destroyed. The non-crystalline variety is identical with that which is obtained from inulin. The power of rotation assigned by Bouchardat(1) to the latter shows that he has obtained it only in the impure state.—Honey contains variable quantities of cane-sugar, which gradually disappear, in consequence of the transmuting power of the ferment present. Honey which is kept in imperfectly-closed vessels, and in cellars, suffers a spontaneous, slow fermentation, by which, in contradistinction to the fermentation caused in dilute solutions by beer-yeast, the uncrystallisable sugar is destroyed first.—In grapes the so-called fruit-sugar is present by which the plane of polarisation is rotated towards the left.—In dried grapes there are found concretions of grape-sugar which rotate the plane of polarisation towards the right; this phenomenon does not depend, as has hitherto been assumed, upon a gradual metamorphosis of the fruit-sugar into grape-sugar, but upon a disappearance of the above-mentioned uncrystallisable sugar, which is caused by its slow fermentation or consumption by insects; both of these actions being principally and first observed in the uncrystallisable sugar.

Soubciran(2) has published the following statements regarding the various kinds of sugar contained in honey:—Bees'-honey submitted to examination contained three different varieties of sugar; viz., grape-sugar; another sugar which diminished in quantity in the honey by keeping and rotated the plane of polarisation towards the right, and was susceptible of being altered by acids; and finally an uncrystallisable sugar which rotated the plane of polarisation towards the left about twice as far as the altered sugar, the ratio at  $13^{\circ}$  being as  $33^{\circ}1$  to  $18^{\circ}9$ . Moreover Soubciran is not of the same opinion as Dubrunfaut, that the altered sugar originally

(1) Annual Report for 1847 and 1848, II, 98.

(2) Compt. Rend. XXVIII, 774; Instit. 1849, 201; J. Pharm. [3] XVI, 252 (in detail); J. Pr. Chem. XLIX, 65.

Mannite.  
Nitro-  
mannite.

consists of two different kinds, but believes that these are only formed by the decomposition of the altered sugar.

**Mannite. Nitro-Mannite.**—Liebig and Pelouze(1) expressed the composition of crystallised mannite by the formula  $C_6H_7O_6$ , which is supported by Favre's statements(2) regarding the mannite-compounds. Knop and Schnedermann(3) have been led, by their investigations of mannito-sulphuric acid, to the conclusion that the composition of crystallised mannite is more correctly expressed by the formula  $C_8H_9O_8$ ; other chemists assume for it the higher formula of Liebig  $C_{12}H_{14}O_{13}$ .—Within the last few years the materials for determining the composition of mannite have been increased by the investigation of the product(4) which is formed from mannite by the action of a mixture of nitric and sulphuric acid, namely, explosive mannite, fulminating mannite or nitro-mannite. Flores Domonte and Menard(5) assign to this compound the formula  $C_{12}H_9O_7 + 5NO_5$ , which is likewise adopted by Stenhouse(6). It admits of the compound being viewed as a substitution-product of mannite,  $C_{12}H_9(NO_4)_5O_{12}$ . L. Svanberg and Staaf(7), who determined only the carbon and hydrogen, adduced the formula  $C_{12}H_9O_9 + 4NO_5$ .

Knop(8) states, in a memoir regarding the equivalent of mannite, that he could not obtain by any process the compounds, described by Favre, of mannite with protoxide of lead, but invariably obtained only a mixture; he likewise considers it probable that the compounds of mannito-sulphuric acid investigated by himself and Schnedermann were only mixtures, and that the results obtained therewith could be but of little avail in determining the composition of mannite. By fusing together an excess of crystallised oxalic acid and mannite at  $110^\circ$ , the temperature being gradually depressed from  $100^\circ$  to  $96^\circ$ , there is formed in 6 or 8 hours, with evolution of formic and carbonic acid, a colourless or yellowish syrup which solidifies on cooling. This substance is a compound of formic acid and mannite which is readily decomposed. Its investigation likewise did not decide the question regarding the composition of mannite. Knop considers the product of the action of nitric acid upon mannite as the only compound which would be likely to

(1) Ann. Ch. Pharm. XIX, 283.

(2) Ann. Ch. Phys. [3] XI, 71; Berzelius' Jahresber. XXV, 557.

(3) Ann. Ch. Pharm. LI, 132; Berzelius' Jahresber. XXV, 561.

(4) Comp. Annual Report for 1847 and 1848, II, 377.

(5) In the Annual Report for 1847 and 1848, we have given the erroneous formula  $C_{12}H_{18}O_7 + 5NO_5$ .

(6) Comp. p. 318.

(7) Svanberg's Jahresber. f. 1847, 360.

(8) J. Pr. Chem. XLVIII, 362; Chem. Gaz. 1850, 81; Ann. Ch. Pharm. LXXIV, 347.

unravel the difficulty; if the composition of this body is represented by the above formula,  $C_{12}H_9(NO_4)_5O_{12}$ , the composition of mannite would in consequence be  $C_{12}H_{14}O_{12}$ . He prefers, as the best method of preparing this product, the process given by Stenhouse(1), namely, to dissolve  $\frac{1}{2}$  oz. of mannite in 2 oz. of well-cooled fuming nitric acid; after a few minutes to add cold hydrated sulphuric acid to the solution surrounded by cold water, until white flocks or grains are no longer separated, and immediately to pour the mixture into a large quantity of water. The crude explosive product thus obtained dissolves in boiling spirit of wine, and may be again obtained from this solution either by crystallisation or mixing it with a very large quantity of cold water. Hydrosulphuric acid, and probably also sulphurous acid, do not act upon explosive mannite in an alcoholic solution. Zinc decomposes it in this solution slowly, iron very readily, particularly in the presence of hydrochloric acid or chloride of ammonium. Explosive mannite yields with potassa a brown product of decomposition (comp. p. 324).

Strecker(2) recommends as the best method of preparing explosive mannite to mix 1 part of finely pulverised mannite with a small quantity of nitric acid of 1.5 sp. gr. until perfect solution is effected, then alternately to add sulphuric and nitric acid until  $4\frac{1}{2}$  parts of nitric and  $10\frac{1}{2}$  parts of sulphuric have been employed; the pasty mass is to be allowed to drain upon a funnel stopped with a glass rod, to be washed with cold water, pressed, and recrystallised from boiling alcohol; water, moreover, precipitates from the acid mixture, which has drained from the funnel, a tolerably large quantity of explosive mannite. Strecker observes that when explosive mannite is kept in a closed bottle for several years, it is decomposed with evolution of red vapours, whilst the product remaining contains nitric acid. He found the composition of the pure preparation to be expressed by the formula  $C_6H_4N_3O_{18}$  or  $C_6H_4(NO_4)_3O_6$ , according to which it may be considered as a substitution-product of mannite,  $C_6H_7O_6$ , and in fact may be termed nitro-mannite. More recent analyses by Strecker also agree better with the latter formula of mannite than with the formula  $C_8H_9O_8$  as formerly proposed by Knop and Schnedermann. It remains undecided whether the above-given formula of mannite must not be raised to  $C_{12}H_{14}O_{12}$ , and that of nitro-mannite to  $C_{12}H_8(NO_4)_6O_{12}$ .—Knop(3) has decided in favour of the latter(4); he is of opinion that nitrogen exists in nitro-mannite as nitric acid and not as hyponitric acid; because the action of concentrated sulphuric acid upon nitro-mannite (by which

(1) Comp. p. 318.

(2) Ann. Ch. Pharm. LXXIII, 59; Chem. Gaz. 1850, 149.

(3) J. Pr. Chem. XLIX, 228; Chem. Gaz. 1850, 149.

(4) Stenhouse likewise assumes for mannite the formula  $C_{12}H_{14}O_{12}$  (comp. p. 318).



Mannite.  
Nitro-  
mannite.

this body is decomposed without any gas being evolved) gives rise to the formation of a colourless solution which when immediately mixed with water yields only a trifling quantity of red vapours; whilst on the other hand large quantities of red vapours are observed when by long standing or application of heat hyponitric acid has been formed. The deportment of nitro-mannite with sulphide of ammonium is likewise different from that of the compounds which contain hyponitric acid. Knop adduces the following as the most probable formulæ of mannite and its derivatives:—

Mannite . . . . .	$C_{12}H_{18}O_6(HO)_6$
Nitro-mannite . . . . .	$C_{12}H_{18}O_6(NO_3)_6$
Mannito-sulphuric acid . . . . .	$C_{12}H_{18}O_6(SO_3)_6 + 3HO + 3HO$
Mannito sulphates . . . . .	$C_{12}H_{18}O_6(SO_3)_6 + 3HO + 3RO$
Formate of mannite . . . . .	$C_{12}H_{18}O_6(2C_2HO_3 + 4HO)$

Reinsch(1) has likewise prepared explosive mannite by introducing finely-pulverised mannite into a cooled mixture of 1 vol. of fuming nitric acid, prepared by distilling equal weights of nitric and sulphuric acid, and  $1\frac{1}{2}$  vol. of common sulphuric acid, until a thick paste was formed; this he gradually immersed in water, and washed and dried it at a temperature not exceeding  $40^\circ$ . On cooling the hot solutions of the product, he obtained it as a granular powder; by spontaneously evaporating the alcoholic solution, it crystallised in star-shaped groups of needles; and by similarly evaporating the ethereal solution, it was obtained of a feathery appearance. On addition of a little potassa-solution to a solution of explosive mannite in alcohol of 90 per cent, containing a portion of ether, there are formed in the cold two strata; from the upper stratum, which has a reddish tint, are deposited delicate yellow, intensely-bitter prisms, which form, with sulphuric acid, a salt crystallising in slender prisms, the base of which is termed by Reinsch *mannitrin*. In the lower brown stratum there appears to be contained only a peculiar acid, which crystallises in needles from its alcoholic solution. On adding potassa to a warm alcoholic solution of explosive mannite, a violent action takes place, attended by a complicated decomposition.

**Explosive Substances from Sugar, Starch, Gum, &c.**—Reinsch, as other chemists previously(2), has obtained explosive products from cane-sugar, milk-sugar, starch-sugar, starch, gum-arabic, and tragacanth, by similar treatment with the mixture of acids mentioned. In working with cane- and milk-sugar, inflammation may take place, if a large quantity of either is rapidly added to the acid, without the requisite agitation and refrigeration. The properties of these explosive substances are more or less similar to those of explosive mannite. The product obtained from cane-sugar comports itself with potassa,

(1) Jahrb. Pr. Pharm. XVIII, 102; Repert. Pharm. [3] III, 6.

(2) Comp. Annual Report for 1847 and 1848, II, 377.

like explosive mannite, and separates only by the spontaneous evaporation of the alcoholic solution which has been prepared in the cold, in fine star-shaped crystals; at other times, in the amorphous state. Reinsch likewise obtained the product from milk-sugar, in the crystalline form; it explodes at as low a temperature as  $75^{\circ}$ .—Vohl(1) was never able to obtain the product from cane-sugar in a crystalline form; but the compound prepared from milk-sugar was invariably deposited from the alcoholic solution in nacreous plates. According to his statement, the latter does not explode at  $75^{\circ}$ ; it contains water of hydration, which is not expelled at  $100^{\circ}$ . On boiling the alcoholic solution of the substance, it is transformed, with assimilation of alcohol, into the amorphous modification.

Regarding nitro-erythro-mannite, which is analogous to nitro-mannite, comp. p. 318.

**Gun-cotton (Pyroxylin).**—Marx(2) has published experiments regarding the temperature at which gun-cotton inflames. He found that the gun-cotton prepared in the ordinary manner explodes even at  $63^{\circ}$ , but on the average at  $94^{\circ}$ , when the temperature is raised, in the space of five minutes, from that of the air ( $20^{\circ}$ ) up to these temperatures. He found, moreover, that when the heating proceeded more slowly, increasing on the average  $3^{\circ}1$  in a minute, the gun-cotton did not explode at all, but commenced at  $69^{\circ}$  to decompose, and by continued decomposition entirely lost its activity.

Maurey(3), who has been engaged in the manufacture of gun-cotton on a large scale, publishes the following practical remarks. In France a kilogr. of gun-cotton cannot be prepared for less than 7 francs; one kilogr. of blasting-powder costs 1 fr. 17 cents; the same quantity of extra fine gunpowder costs 2 frs. 39 cents. To produce an equal effect for the same price, gun-cotton must have six times the effect of the former, and three times that of the latter: 3 grms. of gun-cotton, however, produces the effect of only 5 grms. of extra fine gunpowder. In hard rocks, 1 part of gun-cotton produces the same results as 5 parts of blasting-powder; but in soft limestone, its activity does not exceed that of 2 parts.—Maurey observes, that gun-cotton when kept in closed vessels, and in a dry place, exhibits signs of decomposition after a period of from  $3\frac{1}{2}$  to 9 months: it smelt pungent, and contained formic acid, together with 1.6 to 11.5 per cent of moisture. The decomposition was more perceptible in those specimens of gun-cotton, in the preparation of which the largest quantity of sulphuric acid had been employed, since this acid is never completely removed by washing with pure water. Gun-cotton which had been washed with alkaline water, may be kept from 6 to 7 months without decomposition, but the

Explosive  
substances  
from  
sugar,  
starch,  
gum, &c.

(1) Loc. cit. p. 326.

(2) Pogg. Ann. LXXVIII, 100.

(3) Compt. Rend. XXVIII, 313.

Gun-  
cotton  
(pyroxy-  
lin).

explosion mentioned below, which took place in experimenting upon the gun-cotton which had been washed in this manner, prevented farther observation. In operating upon small quantities, decomposition may be confined merely to a strong evolution of gas, without any explosion taking place. Maurey describes a fearful spontaneous explosion of 1600 kilogr. of the gun-cotton, washed with alkaline water, which had taken place in his manufactory, on the 17th of July, 1848. He is of opinion that we are unacquainted with any method of guarding against the spontaneous explosion of gun-cotton.

Gaudin(1) has published some remarks regarding the different effect of gun-cotton, according as it is prepared with a mixture of nitre and sulphuric acid, or with a mixture of hydrated nitric acid and fuming sulphuric acid. Cotton-wool immersed in the latter mixture only for a few seconds, and washed with a large quantity of water, yields a product which does not propel the ball from a gun, but shatters the barrel to pieces.

Morin(2), in opposition to Pelouze(3), has published some remarks which show that fire-arms, by the use of gun-cotton, are much more rapidly injured than they are by the use of gunpowder; he has, moreover, added some details regarding the uncertain nature of gun-cotton, especially in reference to its preservation, and upon the inadequate effects of explosive paper. In the Annual Report for 1847-8, II, 375, it was stated that an extensive series of experiments had shown the practical applicability of gun-cotton to fire-arms. But regarding a substance, the practical use of which depends so much upon the mode in which it is prepared, it is impossible to pronounce a decided opinion until its chemical nature is established, whereby more correct notions regarding the mode of preparing it are likely to be ensured.

Vohl(4) is of opinion that the insolubility of many kinds of gun-cotton in ether, is probably caused by the too long immersion in sulphuro-nitric acid, especially when the sulphuric acid is in excess, and depends upon the fibres of the gun-cotton becoming surrounded by a substance which is insoluble in ether. On boiling such gun-cotton with alcohol, the latter substance is either dissolved or rendered soluble in ether, by the assimilation of alcohol. On evaporating the alcoholic solution obtained by exhausting gun-cotton with alcohol, it deposited small crystalline grains of a substance, which fused at 70°; this substance became solid again on cooling, and detonated, when struck, or when heated to from 140° to 150°. After once more dissolving the compound in alcohol, it did not crystallise again. It is soluble in ether after it has assimilated alcohol, but

(1) Compt. Rend. XXVIII, 269.

(2) Compt. Rend. XXVIII, 105, 144, 146.

(3) Compt. Rend. XXVIII, 110, 146.

(4) Ann. Ch. Pharm. LXX, 360.

loses this property of solubility when precipitated from its alcoholic solution by water, and maintained in ebullition therewith until the alcohol is completely expelled. It is soluble, without decomposition, in cold concentrated sulphuric acid, and yields by the action of concentrated potassa-solution, with evolution of ammonia, a bright-yellow liquid, which forms a silver mirror when heated with an ammoniacal solution of nitrate of silver.—In order to coat glass flasks with a silver mirror, Vohl(1) proposes to dissolve gun-cotton, or the explosive substance from sugar, mannite, &c., in caustic potassa, by the aid of heat, to add to the brown solution a few drops of nitrate of silver, and then ammonia, until the precipitated oxide of silver is redissolved; it is then to be heated in a water-bath, when, at a certain point of the process, the mixture assumes a blackish-brown colour, froths up, and all the silver becomes deposited upon the walls of the vessel in form of a mirror, which is more brilliant than that which is produced by means of ethereal oils.

Gun-cotton  
(pyroxylin).

**Collodium.**—Regarding the preparation of collodium, Edwards(2) recommends that the action of the acids should not be continued too long, and that dilute acids should be avoided. He, moreover, advises that the ether employed as a solvent of the gun-cotton should not be too pure, and states that a mixture of alcohol and ether of 0.76 to 0.77 sp. gr., dissolves gun-cotton instantly.

**Action of Dilute Nitric Acid upon Woody Fibre.**—Sacc(3) has studied the action of dilute nitric acid upon woody fibre.—On gently boiling 200 grms. of deal sawdust (dried at 100°) with 400 grms. of water, and 2 kilogrs. of common nitric acid, vapours of nitric acid were evolved in the first stage of the process, but disappeared as the operation proceeded. By repeatedly returning the distillate, the wood after a few hours acquired a pasty consistence. The liquid, which contained oxalic acid, was drained off, by placing the mass in a funnel stopped with a glass rod; the remaining product being washed with water. In the process of washing out the acid, the mass which at the commencement still exhibited a woody structure, increased considerably in bulk. The substance was insoluble in water, but on addition of ammonia it formed a solution, which gelatinised when mixed with acids. Sacc considers this mass to be pectic acid, which is formed from the lignin of the wood. When dried at 100°, it assumed a somewhat grey colour, and was then insoluble in ammonia. It yielded, on analysis, from 40.8 to 42.8 per cent of carbon, 5.9 to 6.0 hydrogen, and not a trace of nitrogen: the formula  $C_{14}H_{12}O_{13}$ , which Sacc regards as the true expression of the composition of pectic acid, requires 42.0 per cent of carbon, and

(1) Dingl. Pol. J. CXII, 237.

(2) J. Chim. Méd. [3] V, 511; Dingl. Pol. J. CXIV, 157.

(3) Ann. Ch. Phys. [3] XXV, 218; J. Pr. Chem. XLVI, 430; Chem. Gaz. 1849, 274.

Action of  
dilute  
nitric acid  
upon  
woody  
fibre.

6.0 per cent of hydrogen.—Porter(1) considers it highly improbable that pectic acid, which is so readily decomposed by nitric acid, is formed in this process. On repeating Sacc's experiments, he obtained a mass resembling pectic acid; it presented, however, essential differences from the true pectic acid prepared from turnips. The former was found to be insoluble in boiling water, and to dissolve only with difficulty in alkalis: it was precipitated from the latter solution as a gelatinous precipitate, which, however, soon united in flocks. It was immediately precipitated from its solution in concentrated alkalis, as a white powder; and by boiling with moderately dilute nitric acid, was converted into oxalic acid. True pectic acid, on the contrary, was found to be somewhat soluble in boiling-water, to be precipitated by acids from alkaline solutions as a perfectly transparent jelly, and to yield mucic acid with moderately dilute nitric acid. The substance prepared from wood yielded, when dried at 100°, from 43.2 to 43.6 per cent of carbon, and from 5.8 to 6.0 hydrogen, which most closely corresponds to the formula  $C_{16}H_{12}O_{14}$ . The formula  $C_{32}H_{22}O_{30}$ , which Fremy(2) assumes for pectic acid, requires 42.3 per cent of carbon, and 4.8 per cent of hydrogen.—Kemp(3) supposes that if the substance investigated by Porter is  $C_{16}H_{12}O_{14}$ , the body examined by Sacc may be  $C_{16}H_{13}O_{15}$ .

#### Vegetable Chemistry. Absorption of Inorganic Constituents.

—Lassaigne(4) has collected his earlier investigations(5) with a view of proving that phosphate of lime, just as carbonate of lime, becomes soluble in water by the agency of carbonic acid, and is thus assimilated by plants.

**Root of *Peucedanum Officinale*. Peucedanin.**—Bothe(6) has submitted *peucedanin* to a new investigation. It was first prepared by Schlatter(7), and subsequently analysed by O. L. Erdmann(8). In order to prepare and purify this substance he recommends the following method:—The root of *Peucedanum officinale*, finely pulverised, is digested for some hours with alcohol of 90 per cent, and then heated with the liquid to ebullition; the filtered solution when

(1) Ann. Ch. Pharm. LXXI, 115; Sill. Am. J. [2] IX, 20; Chem. Gaz. 1849, 469.

(2) Annual Report for 1847, and 1848, II, 103.

(3) Chem. Gaz. 1849, 487.

(4) Ann. Ch. Phys. [3] XXV, 346; J. Pharm. [3] XV, 258; J. Pr. Chem. XLVI, 479; Compt. Rend. XXVIII, 73 (in abstr.); Instit. 1849, 18.

(5) Annual Report for 1847 and 1848, II, 119.

(6) J. Pr. Chem. XLVI, 371; Ann. Ch. Pharm. LXXII, 308. (In the latter place, important errors in Bothe's calculations of the analysis, and stoichiometrical consideration, have been pointed out.)

(7) Ann. Ch. Pharm. V, 201; Berzelius' Jahresbericht XIV, 323.

(8) J. Pr. Chem. XVI, 42; Berzelius' Jahresbericht XX, 446.

evaporated to a slight extent yields crystals of peucedanin which are freed from a brown resinous substance by very dilute cold alcohol, in which it dissolves. The subsequent extracts contain a far larger quantity of the resinous substance. Peucedanin is separated by diluting the hot alcoholic extract with water as long as the cloudiness which is produced disappears by agitation and heat; the cooled liquid deposits additional crystals on long standing. Peucedanin is purified by repeated recrystallisation from cold ether which leaves a portion of oxipeucedanin undissolved. Pure peucedanin crystallises in small six-sided prisms which belong to the rhombic system. They fuse at  $75^{\circ}$  without loss of weight; at  $130^{\circ}$  they acquire a brown colour with formation of a trifling sublimate; they are expressed by the formula  $C_4H_2O$ . Bothe adopts the formula  $C_{24}H_{12}O_6$ . It does not appear to form compounds of definite composition with bases; it dissolves however in alkalis and is again precipitated by acids. In the recrystallisation of peucedanin from cold ether, *oxipeucedanin* remains, as above-mentioned, in form of a granular residue; when freed from peucedanin by cold ether, it fuses at  $140^{\circ}$  and has then the composition  $C_{24}H_{11}O_7$ . Bothe considers it as being derived from peucedanin by oxidation and separation of water, and states that old roots contain a larger quantity than roots which are freshly gathered. The author did not succeed in preparing it artificially.—Peucedanin slowly dissolves at  $60^{\circ}$  in nitric acid of 1.21 sp. gr.; the yellow liquid solidifies on cooling to a foliaceous crystalline mass which is recrystallised from alcohol. *Nitropeucedanin*, the product thus obtained, forms colourless, pliable crystalline plates which are pretty readily soluble in alcohol and in ether, and are nearly insoluble in water; heated above  $100^{\circ}$  they fuse and are decomposed. Bothe adduces for this compound the formula  $C_{24}H_{10}NO_9$ , but his analyses, when correctly calculated, do not accurately agree therewith nor with the formula  $C_{24}H_{11}(NO_4)O_6$ , according to which nitropeucedanin would be a substitution-compound of peucedanin. In the preparation of nitropeucedanin oxalic and styphnic acid are likewise formed.—*Nitropeucedaninamide* is the name assigned by Bothe to a compound which is formed when nitropeucedanin is heated to  $100^{\circ}$  in a current of ammonia-gas. He represents its composition by the formula  $C_{24}H_{12}N_2O_8$ , according to which it may be derived from nitropeucedanin,  $C_{24}H_{10}NO_9$ , by the assimilation of  $NH_3$  and separation of  $HO$ ; and he adduces in support of his view numbers obtained in observing the change of weight of nitropeucedanin when exposed to this action. His numbers however directly contradict his statements. Nitropeucedaninamide is soluble in alcohol and crystallises from the hot solution in shining rhombic prisms; it is soluble also in ether, and almost insoluble in water. On adding water to the alcoholic solution it separates slowly; the slightly clouded liquid is observed to be yellow in transmitted light and of a sky-blue colour

Columbo-  
root.

in reflected light. This compound is likewise formed in an impure state, in smaller quantity, by heating nitropeucedanin with ammonia and alcohol. It is decomposed by acids with formation of nitropeucedanin and an ammonia-salt of the acid employed; when boiled with strong bases it slowly evolves ammonia.

**Columbo-Root.**—Wittstock in 1830(1) found in columbo-root (of *Cocculus palmatus* de Cand., *Menispermum palmatum*, Linn.) a peculiar substance which he termed *columbin*. Its crystalline form was determined by G. Rose(2). Liebig's(3) analysis, calculated according to the new atomic weights, yielded 65·53 per cent of carbon, and 6·17 per cent of hydrogen.—Bödeker(4) recommends the following process for preparing columbin. Columbo-root is exhausted by alcohol of 75 per cent; as much as possible of the alcohol is distilled from the clear extract, and the last traces are expelled by drying the residue in a water-bath. It is then treated with water, and the thickish, cloudy solution agitated with an equal volume of ether; the greater part of the ether is distilled from the filtered ethereal stratum, and again agitated with the aqueous stratum, the process being repeated until the ether no longer removes from the aqueous stratum an appreciable quantity of columbin. The columbin separates on evaporation in the crystalline form from the ethereal solution which contains also a fatty oil, and is purified by recrystallisation from ether. The columbin is readily ascertained to be free from fat by dissolving it in boiling acetic acid in which no droplets of oil should be observed. Bödeker found in columbin 65·1 and 65·3 per cent of carbon, 6·0 of hydrogen: he assumes it to be represented by the formula  $C_{42}H_{22}O_{14}$  which requires 65·3 per cent of carbon, and 5·7 of hydrogen. A compound sufficiently pure to enable the author to determine its equivalent could not be prepared.—As stated in the Annual Report for 1847-8, I, 490; Bödeker found columbin to be accompanied in columbo-root with berberine, for which he confirmed the composition  $C_{24}H_{18}NO_9$ . If the residue of the alcoholic extract of columbo-root is exhausted with hot lime-water the brownish-red extract yields immediately an amorphous precipitate when neutralised with hydrochloric acid, and the supernatant liquid when mixed with a farther quantity of hydrochloric acid deposits after some days hydrochlorate of berberine in the crystalline form. A compound similar to the above-mentioned amorphous precipitate is formed by digesting the aqueous solution of the alcoholic extract of columbo with an acid previously to the separation of the berberine-salt. This amorphous precipitate is freed from the

(1) Pogg. Ann. XIX, 298; Berzelius' Jahresber. XI, 288.

(2) Pogg. Ann. XIX, 441.

(3) Pogg. Ann. XXI, 30.

(4) Ann. Ch. Pharm. LXIX, 37; Chem. Gaz. 1849, 149.

berberine-salt by washing with water, and is dissolved in acetic acid which deposits by gradual evaporation a portion of columbin and then a resinous yellow mass. The latter is exhausted by ether, the residue dissolved in dilute potassa-solution, the brown flocks which separate on passing into the liquid a stream of carbonic acid are filtered off, and the solution decomposed by hydrochloric acid. The floccy white precipitate forms when washed a pale straw yellow, amorphous powder which consists of *columbic acid*. This acid reddens moistened litmus-paper, scarcely dissolves in water, is slightly soluble in cold ether, more readily in acetic acid and most copiously in alcohol; it does not, however, crystallise. According to Bödeker its composition at  $40^{\circ}$  is  $\text{HO}, \text{C}_{42}\text{H}_{21}\text{O}_{11} + 3 \text{HO}$ ; 1 equiv. of water is expelled by drying at  $100^{\circ}$ ; and 2 equivs. at  $115^{\circ}$ . It is not altered by cold nitric acid; it dissolves however in concentrated sulphuric acid without being decomposed. The alcoholic solution yields with a solution of acetate of lead in alcohol a yellow precipitate of the composition  $2 (\text{PbO}, \text{C}_{42}\text{H}_{21}\text{O}_{11}) + \text{PbO}, \text{HO} + 5 \text{HO}$ , from which the 5 HO are expelled at a temperature between  $100^{\circ}$  and  $130^{\circ}$ . According to Bödeker the columbic acid is present in columbo-root in combination with berberine.

**Root of *Aristolochia Clematidis*.**—Winckler(1) obtained on investigating the root of *Aristolochia clematidis*, Linn. (*Aristolochia longa vulgaris*), an ethereal oil in quantity of 120 grains from 4 pounds of roots, and a bitter substance which is identical with that which is contained in the root of *Aristolochia serpentaria* Linn.

**Tubers of *Apios Tuberosa*.**—Richard(2) recommends the cultivation of *Apios tuberosa* de Cand. (*Glycine apios*, Linn.) as a substitute for the potato. He gives an analysis by Payen, according to which the tubers of this plant (A) compared with a variety of potato (*Patraque jaune*; B) contain in 100 parts:

	A.	B.
Nitrogenous substances . . . . .	4.5	1.7
Fatty substances . . . . .	0.8	0.1
Starch, sugar, and pectin-substances . . . . .	33.55	21.2
Cellulose and epidermis . . . . .	1.3	1.5
Inorganic constituents . . . . .	2.25	1.1
Water . . . . .	57.6	74.4

**Topinambour.**—Payen, Poincot and Fery(3) have analysed topinambour. The product investigated was cultivated in a sandy soil which had been manured with phosphate of magnesia-ammonia. They found it to contain 76.04 per cent of water, 14.70 sugar; 3.12 albumin and two other nitrogenous constituents; 1.50 cellulose; 1.86 inulin; 0.92 pectic acid; 0.37 pectin; 0.20 fat

(1) Jahrb. Pr. Pharm. XIX, 71.

(2) Compt. Rend. XXVIII, 189; Instit. 1849, 76.

(3) J. Pharm. [3] XVI, 434.



Bark of  
cail-cedra.

with traces of volatile oil; and 1.29 ash (comp. at Ashes of Plants).

**Bark of Cail-cedra.**—E. Caventou(1) has investigated the bark of *cail-cedra* (*Khaya senegalensis* or *Swietenia senegalensis*) which is employed in the neighbourhood of the River Senegal as a remedy for intermittent fevers. He found it to contain a bitter principle which he terms *cail-cedrin*, besides a green fat, red and yellow colouring matters, gum, starch, a waxy substance, woody fibre, sulphate and phosphate of lime, and chloride of potassium.

**Sugar-Cane.**—Casaseca(2) has investigated the fresh sugar-cane (*canne créole*) of Havannah, and found the entire cane (A), the stripped cane (B) and the cuticle (C) to consist of the following constituents:

	A.	B.	C.
Water . . . . .	77	77.8	69.5
Sugar and other soluble substances	12	16.2	11.5
Woody substance . . . . .	11	6.0	19.0

23 parts of dried sugar-cane contain 12 of sugar, 23 of the dried cuticle, however, contained only 8.6 parts. The advantage of peeling the sugar-cane consists principally in the removal of the woody substance. Casaseca persists in his opinion that the ratio of sugar to the woody substance is constant in the ripe cane, and that in the same quantity of perfectly dried sugar-cane there is always an equal proportion of sugar present. 1000 parts of freshly-peeled sugar-cane yielded 1.6 of ash which consisted of 68.6 parts of silica to 31.4 of lime, with traces of iron and manganese. 1000 parts of the fresh cuticle yielded 2.28 of ash consisting of 68.9 of silicic acid with a large quantity of silicate of iron and a little silicate of manganese, and of 31.1 of lime, together with iron and manganese.

Payen(3) has published investigations regarding the structure and composition of the sugar-cane. We must however confine ourselves to the chemical results which he has obtained. He found in the ripe sugar-cane of Otaheite 71.04 per cent of water: 18.02 sugar; 9.56 cellulose and woody substance; 0.55 albumin and three other nitrogenous substances; 0.35 cerosin, green matter, yellow colouring matter, colouring principles which assumed a brown and red colour, fatty substances, volatile oil, aromatic and deliquescent substances; 0.12 insoluble and 0.16 soluble salts consisting of phosphate of lime and magnesia, alumina, sulphate and oxalate of lime, acetate and malate of lime, potassa and soda, sulphate of potassa; chloride of potassium and sodium; and finally 0.20 silicic acid. In the unripe

(1) J. Pharm. [3] XVI, 355; J. Chim. Méd. [3] V, 673; Repert. Pharm. [3] IV, 397.

(2) Ann. Ch. Phys. [3] XXV, 321.

(3) Compt. Rend. XXVIII, 613.

sugar-cane which had attained one-third of its perfect development he found 79·70 per cent of water ; 9·06 sugar ; 7·03 cellulose and woody *matière incrustante* ; 1·17 albumin and three other nitrogenous principles ; 1·09 starch, cerosin, green substance, yellow colouring matter, and substances which acquired a brown and red colour ; 1·95 fatty and aromatic substances, hygroscopic matter, volatile oil, soluble and insoluble salts, silica and alumina.—Payen moreover alludes to the different proportions of solid substance in the various parts of the sugar-cane.

Sugar-cane.

In regard to the latter circumstance, Casaseca(1) has published the following statements. The proportion of water in sugar-cane increases continually towards the summit ; sugar occurs in larger quantity in the lower than in the upper portion of the cane, although it is nearly uniformly distributed in the upper two-thirds ; in the lower two-thirds the proportion of woody substance is nearly equal, but far less in the upper two-thirds. The proportion of sugar in the middle third corresponds pretty accurately to that of the entire cane. The joints contain less water than the other portions of the cane, but even in those parts the proportion of water increases towards the top of the cane.

**Cardamine Amara.**—Winckler(2) has investigated the dried plant of *Cardamine amara*, Linn. He has found it to contain a nitrogenous and sulphuretted acid in combination with an organic compound which is probably of a basic character. In its chemical constitution it is probably identical with or only very slightly different from myronic acid of mustard-seed. Alone and in combination with bases this acid evolves by the action of the myrosin of yellow mustard, but not by emulsion of almonds, a pungent volatile oil which is very similar to or identical with the oil of scurvy-grass or of horse-raddish. He states that the remarkable bitterness and far inferior pungency of the fresh plant is dependent on the presence in smaller proportion of myrosin or of an analogous compound which is required to produce the pungent oil.

**Cochleria Officinalis.**—The dried plant of *Cochleria officinalis*, Linn., according to Winckler's(3) investigation, comports itself in many respects like the preceding plant. He states that it contains a substance forming with lime a soluble compound which is decomposed by free lime at a high temperature. When treated with basic acetate of lead the substance combines with the protoxide of lead, and may be separated from its combination by means of sulphuretted hydrogen without being thereby decomposed. It is probable that the formation of the pungent ethereal oil is dependent on the simultaneous action of myrosin and a basic body upon this peculiar substance.

(1) Compt. Rend. XXIX, 234.

(2) Jahrb. Pr. Pharm. XVIII, 89.

(3) Jahrb. Pr. Pharm. XVIII, 319.

Leaves of  
the mul-  
berry-tree.

**Leaves of the Mulberry-Tree.**—Ragsky(1) found the same proportion of ash in the dark-green as in the yellowish leaves of the mulberry-tree, the colour of the leaves being merely dependent on the nature of the soil and culture. The ash, which amounted nearly to 10·3 per cent, consisted chiefly of carbonate of potassa, chloride of potassium, carbonate of lime, a small quantity of phosphate of lime, sulphuric acid and magnesia with minute quantities of silicic acid and sesquioxide of iron. But in the yellow leaves, dried at 100°, if assumed to be free from ash, he found from 1·6 to 2 per cent of nitrogen, and in the green leaves 4·0 per cent.

**Leaves of Agave Americana.**—Lenoble(2) found in the leaves of *Agave Americana* a pungent, vesicating volatile oil, a gummy, resinous constituent, woody fibre, silicic acid and salts of potassa and lime, which consisted chiefly of the malates of these bases.

**Liquid in the Ascidia of Nepenthes.**—A. Völcker(3) has investigated the liquid contained in the ascidia of *Nepenthes*. It was generally clear and colourless, rarely yellowish, and reddened litmus; that which was collected from different plants yielded respectively 0·92; 0·91; 0·87; 0·58; 0·62; and 0·27 per cent of residue which contained in 100 parts 38·61 per cent of organic matter consisting principally of malic acid with a little citric acid; 50·42 of chloride of potassium, 6·36 soda, 2·59 lime and 2·59 magnesia.

**Milky Juice of Asclepias Syriaca. Asclepione.**—List(4) has examined a peculiar substance contained in the white milky juice of *Asclepias syriaca*, and has termed it *Asclepione*. The milky juice which exudes abundantly from the exposed surface after the plant is cut off is very concentrated, thick, and possesses a slightly acid reaction. When heated the albumin it contains coagulates and encloses the suspended particles of asclepione which may be separated by digestion with ether. After distilling off the greater part of the ether, there remains a clear solution which solidifies on farther evaporation to a crystalline mass. The asclepione which is thus prepared still contains another substance which by treatment with anhydrous ether remains insoluble. Pure asclepione forms white crystalline cauliflower-like masses, and by the slow evaporation of its solution it exhibits a finely radiated, concentric crystallisation. It is tasteless and odourless, insoluble in water and in alcohol, readily soluble in ether, but less soluble in turpentine-oil, petroleum and concentrated acetic acid. It is neither dissolved nor decomposed by hot potassa-solution. It fuses at 104° and then remains amorphous and transparent; when more strongly heated it assumes a yellow colour and is decomposed. Its composition is expressed by the formula

(1) Wien. Acad. Ber. 1849, Jan.-51.

(2) J. Pharm. [3] XV, 349.

(3) Annals and Magazine of Natural History [2] IV, 128; Phil. Mag. [3] XXXV, 192; J. Pr. Chem. XLVIII, 245.

(4) Ann. Ch. Pharm. LXIX, 125.

$C_{20}H_{17}O_3$  or, with reference to the analogous lactucon ( $C_{40}H_{32}O_3$ ), by  $C_{40}H_{34}O_6$ .

New variety of manna.

**New Variety of Manna.**—Th. Anderson(1) has investigated a new variety of manna which at certain seasons covers the leaves of *Eucalyptus dumosa*, a tree which grows in the interior of Australia Felix, and is called by the natives *lerp*. It appears to be uncertain whether it exudes spontaneously, or as the result of the punctures of insects. This kind of manna consists of small conical cups covered externally with hairs. The alcoholic extract could not be made to crystallise; it contains an uncrystallisable sugar which is susceptible of alcoholic fermentation. The residue when treated with cold water yields a gummy substance, and with hot water a substance which on cooling separates as a white powder and is identical with inulin, as was also proved by analysis. The substance dried at  $100^\circ$  gave 43.9 per cent of carbon and 6.3 hydrogen. The liquid from which the inulin had been separated acquired a blue colour with iodine; and the cellulose remaining after treatment with water yielded 43.7 per cent carbon and 7.0 hydrogen. This kind of manna generally contains in addition small quantities of resin and wax, and leaves when burned 1.13 per cent of ash. It consists in 100 parts of 15.01 water; 49.06 sugar with a small quantity of a resinous substance; 5.77 gum; 4.29 starch; 13.80 inulin; 12.04 cellulose.

**Formation of Fat in Olives.**—Blondeau de Carolles(2) believes that the formation of fat in olives depends upon a decomposition of woody fibre and tannic acid with separation of carbonic acid and water. He expresses this metamorphosis by an equation in which the olive-oil, as obtained from the olives, figures as a pure chemical compound of the formula  $C_{36}H_{36}O_4$ .

**Gourd Fruit.**—Girardin(3) has investigated the fruit of several varieties of gourd; common gourd (A), *pain du pauvre* (B), *artichaut de Jérusalem* (C), *giraumont bonnet turc* (D) and *sucrine du Brésil* (E). The variety which is termed *pain du pauvre* is different from that of the same name investigated by Braconnot(4). Girardin found in 100 parts of the fresh fruit:

	A.	B.	C.	D.	E.
Water . . . . .	94.18	79.67	85.80	92.94	93.40
Sugar . . . . .	0.27	2.50	0.15	0.69	0.33
Albumin and casein . . . . .	0.16	1.36	0.41	0.14	0.19
Fat and colouring matter . . . . .	trace	0.01	0.01	0.01	trace
Gum, woody substance, &c. . . . .	2.94	12.60	7.85	2.09	2.65
Ash . . . . .	2.45	3.86	5.78	4.13	3.43
Nitrogen . . . . .	0.027	0.218	0.066	0.022	0.031

(1) Edinburgh new Philos. Journ., July, 1849; J. Pr. Chem. XLVII, 449; J. Pharm. [3] XVI, 235.

(2) Instit. 1849, 194; Forriep's Tagesberichte über die Fortschritte der Natur- und Heilkunde, 1850, Nr. 121.

(3) J. Pharm. [3] XVI, 19.

(4) Annual Report for 1847 and 1848, II, 125.

Guard  
fruit.

besides traces of free acid, an aromatic principle and starch. The ashes contain as soluble salts carbonate of potassa which is derived from the malate, sulphate of potassa, chloride of potassium and chloride of magnesium; and as insoluble salts, phosphate of lime and magnesia, carbonate of lime and magnesia, silicic acid, alumina and sesquioxide of iron.—It is worthy of remark that part of these fruits contain more ash than organic matter.

**Acorns.**—Braconnot(1) has found in shelled acorns, obtained from *Quercus racemosa* and *sessiliflora*, 31·80 per cent of water, 36·94 starch, 1·90 lignin, 15·82 legumin and tannin, 5·00 extractive matter, 7·00 uncrystallisable sugar, 3·27 fatty oil, 0·38 potassa, 0·19 sulphate of potassa, 0·01 chloride of potassium, 0·05 phosphate of potassa, 0·27 phosphate of lime (the sum of these constituents is 102·63); traces of silicic acid and sesquioxide of iron, undetermined quantities of citric acid and milk-sugar. Braconnot lays great stress upon the occurrence of the latter constituent. He considers that the existence of a substance in acorns closely allied to milk-sugar, can scarcely be doubted; when treated, however, with nitric acid, it yielded no mucic acid.

**Coffee-Berries.**—In a memoir upon coffee, Payen(2) has collected the results of several papers which he had published at former periods. We shall give here merely the composition he states that coffee presents in the normal condition; namely, 31 per cent cellulose; 12 hygroscopic water; from 10 to 13 fat; 15·5 sugar, dextrin and vegetable acid; 10 legumin and casein; from 3·5 to 5 tanno-caffate (chlorogate) of caffeine-potassa; 3 of a nitrogenous substance; 0·8 free caffeine; 0·001 of solid volatile oil; 0·002 of an aromatic fluid constituent soluble in water, and possessed of an agreeable flavour, and a less soluble aromatic constituent; and 6·697 of inorganic constituents consisting of potassa, lime, magnesia, silicic acid, phosphoric acid, sulphuric acid, and traces of chlorine.

**Seeds of the Ivy.**—Posselt(3) has published a preliminary note regarding the constituents of ivy-seeds (*Hedera helix* L.) They contain a nitrogenous substance resembling emulsin, fat, two peculiar acids, sugar, together with some pectin and inorganic salts.—Ether extracts from the fresh seeds a green oil, besides a fluid fat which contains one that is solid. The latter saponifies with difficulty, and yields thereby a fatty acid, possessing a fusing-point which does not rise above 30°, after repeated recrystallisation from alcohol; its silver-salt contains from 27·4 to 27·6 per cent of silver. The seeds exhausted by ether were treated with boiling alcohol. After distilling off a portion of the alcohol from the extract a substance was deposited in quantity, and on cooling the liquid

(1) Ann. Ch. Phys. [3] XXVII, 392; J. Pr. Chem. XLIX, 232.

(2) Ann. Ch. Phys. [3] XXVI, 108.

(3) Ann. Ch. Pharm. LXIX, 62; Chem. Gaz. 1849, 92.

at this point of the operation, an indistinctly crystallised yellowish substance separated, and was found to consist of impure *hederic acid*. From an alcoholic solution mixed with ether, this acid once crystallised in white needles and plates of perfect purity. It dissolves neither in water nor in ether; its alcoholic solution has an acid reaction. It expels carbonic acid from its combinations, and forms with bases uncrystallisable salts, most of which are insoluble in water, but are soluble in alcohol. It loses at 100° 5·4 per cent of water of crystallisation, and when dried at this temperature contains from 66·4 to 66·5 per cent of carbon, and from 9·4 to 9·5 hydrogen. To *hederic acid* adheres pertinaciously another acid, which is, moreover, retained in quantity in the seeds which have been exhausted by water and alcohol; it may be separated therefrom by extraction with acetic acid. It forms insoluble salts with lead and baryta, and soluble yellow salts with the alkalies. When heated with nitrate of silver, or with nitrate of suboxide of mercury, it reduces them to the metallic state.

**Seeds of *Lathyrus Angustifolius*.**—Reinsch(1) has found in the seeds of *Lathyrus angustifolius* an uncrystallisable bitter substance, vegetable fibre, starch, vegetable gelatin, vegetable albumin, gum, salts, a fatty oil, a resinous and waxy substance.

**Semen Cynæ. Santonin.**—Calloud(2) recommends the following method of preparing santonin: 10 kilogrs. of worm-seeds are boiled with 80 liters of water, and 600 grms. of caustic lime; the liquid is separated by a straining-cloth from the deposit, and the latter is repeatedly treated in a similar manner. The liquid is then separated by filtration from the colouring matter which is slowly deposited, the fluid is evaporated down to about 10 or 12 liters, and mixed with an excess of hydrochloric acid. The impure santonin, which is deposited in 4 or 5 days, is washed with about 1 liter of hot water, and suspended in 50 grms. of aqueous solution of ammonia, which dissolves out a resinous matter. It is finally washed with cold water, heated to ebullition with about 3 liters of strong alcohol, to which some animal charcoal is added, when the santonin crystallises from the hot filtered liquid in a state of purity.

***Rhamnus Frangula* and *Rhamnus Cathartica*.**—Binswanger(3) has subjected to a lengthened investigation the sap of the berries, the seeds, the stem- and root-bark of *Rhamnus frangula* and *Rhamnus cathartica*, for the details of which we must refer to the original memoir. We merely state that he likewise found in the unripe, but not in the ripe berries of *Rhamnus cathartica*, the crystallisable substance discovered therein by Fleury(4), who termed it

(1) Jahrb. Pr. Pharm. XVIII, 37.

(2) J. Pharm. [3] XV, 106; Ann. Ch. Pharm. LXXII, 316 (in abstr.)

(3) Repert. Pharm. [3] IV, 47, 145.

(4) J. Pharm. [2] XXVII, 666; Berzelius' Jahresber. XXII, 462.

*Rhamnus*  
*frangula*  
and  
*Rhamnus*  
*cathartica*.

**rhamnin.**—Lassaigne and Feneulle(1) had termed the purgative principle of senna-leaves *cathartin*, and Hubert(2) had regarded the bitter principle of the ripe berries of *Rhamnus cathartica*, as agreeing with the latter constituent of senna; Binswanger, however, differs from these views, and distinguishes a rhamno-cathartin and a senna-cathartin.—Winckler(3) also has found no rhamnin in the ripe berries of *Rhamnus cathartica*, but merely a bitter substance which he terms cathartin. He believes that during the perfect ripening of the berries, the rhamnin is split into this bitter principle and grape-sugar. Winckler(4) also found that this bitter substance differs from that obtained from senna-leaves (*Sennæ tripolitanæ*).

Regarding the analyses of plants and of ashes, comp. also at Agricultural Chemistry.

**Proximate Constituents of the Animal Body and Collateral Matters. Allotropism of the so-called Protein-Substances.**—

In a treatise upon the allotropism of the constituents of animal bodies, Draper(5) has pointed out two different species of allotropy which might be exhibited by fibrin, albumin and casein: either, firstly, they may all be allotropic modifications of one and the same compound, analogous to the different modifications of carbon (charcoal, graphite, diamond); or, secondly, each of these substances may exist in two states, a chemically-active, and a chemically-passive state. The ultimate atoms of each substance may be brought into the active or passive condition by the influence of the nervous system. In inflammatory diseases, according to this view, the atoms of the parts affected are in the active, and in congestive diseases, in the passive state; in the first case, the increased affinity of these atoms for oxygen will give rise to an energetic process of oxidation, manifesting itself in an augmented excretion of urea and sulphuric acid in the urine, &c.; in the second case the result will be reversed. (The question concerning allotropic conditions certainly could only arise if these so-called protein-compounds possessed actually the same composition.)

**Fibrin.**—Liebig(6), on comparing the fibrin obtained from muscular fibre with that of blood, with which it is usually considered identical, has found them essentially different.—The fibrin of blood, when placed in water containing  $\frac{1}{100}$ th per cent of hydrochloric acid, soon swells up to a gelatinous mass which shrinks together again on the addition of stronger acid, and again swells up in pure water without dissolving to any perceptible extent.—The fibrin of flesh dissolves, in great part, at the ordinary temperature, in water con-

(1) Ann. Ch. Phys. [2] XVI, 18.

(2) J. Chim. Méd. [1] VI, 193.

(3) Jahrb. Pr. Pharm. XIX, 221.

(4) Jahrb. Pr. Pharm. XIX, 263.

(5) Phil. Mag. [3] XXXIV, 241.

(6) Ann. Ch. Pharm. LXXIII, 125; Chem. Gaz. 1850, 169.

taining the above-mentioned amount of acid (that from fowls and oxen almost entirely, that from mutton leaves more residue; the fibrin prepared from veal leaves a residue amounting to more than one half; the residue is elastic and appears whiter and more gelatinous than blood-fibrin which has been steeped in water containing hydrochloric acid); it produces rather a thick solution, somewhat turbid from fatty matters, which filters with difficulty, and when neutralised, coagulates to a thick white gelatinous paste which dissolves easily in excess of alkali; chloride of sodium and other salts, added to the solution, produce a coagulum which redissolves in much water. The precipitate produced by neutralising the hydrochloric solution dissolves (unless previously boiled with water) in lime-water; the solution is coagulated, on boiling, like a dilute solution of albumin. The fibrin of flesh contains less nitrogen than that of blood, and in composition more nearly resembles albumin. Fibrin from the flesh of fowls (which had been dissolved in hydrochloric acid, precipitated by ammonia and dried at  $120^{\circ}$ ) contained 54.46 per cent carbon, 7.28 hydrogen, 15.84 nitrogen, 1.21 sulphur and 1.4 ash; the fibrin from beef contained 53.67 per cent carbon, 7.27 hydrogen, 16.26 nitrogen and 1.06 sulphur.

Liebig could not by any method prepare the fibrin of blood so as to be free from iron; even when the ash left after incineration was quite white, it contained a considerable quantity of iron. Well-washed blood-fibrin covered with water in a closed vessel, and set aside in a warm place, soon enters into putrefaction (in which process there is produced, together with very little free hydrogen gas, a very volatile stinking substance); without changing colour, it loses its coherence, and after three weeks is converted into a nearly colourless liquid, in which a few flocks tinged black with sulphide of iron float; the liquid behaves like a solution of albumin, coagulating when heated, to a gelatinous mass which exhibits the properties and composition of albumin (dried at  $130^{\circ}$  this mass contained 53.9 per cent carbon, 6.99 hydrogen, 15.58 nitrogen, 1.45 to 1.59 sulphur and 0.28 ash). The solution filtered from the coagulated albumin contained a small quantity of a nitrogenised substance which was not examined.

**Casein.**—Schlossberger(1) believed that he had succeeded in decomposing casein into two different substances. He coagulated milk with hydrochloric acid, washed the coagulum first with dilute hydrochloric acid and afterwards with water, when it first became gelatinous and finally dissolved; a small quantity of carbonate of ammonia produced a precipitate in this solution, and the liquid, when filtered from this, was again precipitated on the addition of hydrochloric acid. Schlossberger considered these two



Casein.

precipitates as perfectly distinct substances. Berzelius(1) has already remarked that the first precipitate is probably casein free from hydrochloric acid, the other, casein containing hydrochloric acid, and that possibly the former might be converted into the latter by solution in carbonate of ammonia, and reprecipitation by hydrochloric acid.

Bopp(2) found that when milk mixed with an equal quantity of water was treated with dilute hydrochloric acid, until it separated into a voluminous curd and a clear yellowish liquid, a precipitate was formed, which differed even in outward appearance from that produced by acetic acid; this precipitate is separated from the liquid by means of a linen strainer, repeatedly diffused in water containing between 2 and 3 per cent of hydrochloric acid, again separated from the liquid and washed with pure water; it now swells up, becomes gelatinous, and dissolves when diffused in a sufficient quantity of water at about 40°. The solution contains hydrochloric acid, and is precipitated both by acids and alkalies. With hydrochloric acid it furnishes a coagulum which does not (like the precipitate produced in a solution of casein by acetic acid) become denser in alcohol, but swells up, and, if a sufficient quantity of the latter be employed, dissolves; from this solution ether precipitates it in dazzling white flakes containing hydrochloric acid, which become denser when treated with fresh ether, but swell up in water, and in a sufficient quantity, dissolve entirely. Casein evidently forms two compounds with hydrochloric acid; the one which contains most hydrochloric acid is insoluble; the other (produced from the preceding by the action of water) is soluble. Alkaline carbonates produce a precipitate in solutions of both these compounds, which redissolves in excess of the precipitant, becomes denser in alcohol, and contains only traces of chlorine. Of the two substances obtained by Schlossberger, one was casein containing hydrochloric acid, whilst the other was free from it.—The precipitate produced by hydrochloric acid cannot be thoroughly washed with water, it putrefies very slowly (at first merely becoming mouldy); that obtained with an alkaline carbonate (and employed for the experiments cited at page 341) is easily washed with water, and soon enters into putrefaction.(3)—

(1) Berzelius' Jahresber. XXVII, 636.

(2) Ann. Ch. Pharm. LXIX, 16; Chem. Gaz. 1849, 158.

(3) The cheese coagulated by rennet differs materially from that separated from milk by addition of an acid; the latter dissolves easily in alkaline carbonates, whilst that precipitated by rennet is insoluble in these reagents, or dissolves only after protracted ebullition. In the coagulation of milk by rennet, the cheese is separated from a neutral or slightly alkaline solution, and retains, chemically combined with it, all the phosphates of lime and magnesia which are contained in the milk. In consequence of its combination with these substances, the cheese loses its ready solubility in alkaline carbonates. On the other hand, if milk is precipitated by acids, so that part of the acid remains in excess, or if the cheese separated by rennet be treated with dilute sulphuric acid, the

Bopp recommends the method above described for the preparation of casein almost free from fat without the use of ether or alcohol.—The filtrate obtained after precipitating the milk with excess of hydrochloric acid, gives, with excess of carbonate of soda, a gelatinous precipitate, which dries up to a powder, and contains much phosphoric acid, lime and magnesia, together with an organic substance; this latter is probably casein, which is insoluble in the alkaline carbonate in consequence of its combination with the phosphates.

**Emulsin.**—Bull(1) has examined emulsin. The method which he adopted for preparing this substance was essentially that proposed by Orloff.(2) The almonds freed from oil are bruised with water and allowed to stand in a warm place till acid fermentation has commenced, when the emulsin may be precipitated from the solution by alcohol. Bull obtained the best result by the following process. The finely bruised sweet almonds were freed from oil by expression, mixed into an emulsion, at first with twice their weight and afterwards with an equal weight of water, and each time the liquid was separated from the residue by expression; the liquid left to itself in a loosely covered vessel at 20° or 25° separates after twelve hours into two parts, a creamy coagulum forming on the surface; from the lower watery layer the emulsin may be precipitated by adding twice the volume of alcohol of 85 per cent, either immediately or after first filtering off the precipitate produced by acetic acid (after two or three days the aqueous solution no longer gives a precipitate with acetic acid). From 1 pound of almonds, Bull obtained about 6 grms. of emulsin. If no larger quantity than this be prepared at once, and the precipitated emulsin be immediately washed, first with strong spirit, and lastly with absolute alcohol, expressed, and rapidly dried in thin layers *in vacuo* over sulphuric acid, it is obtained as a white friable mass; when larger quantities are prepared and more slowly dried (especially when dried in the air), the emulsin appears as a gummy, friable, dark or reddish-brown mass. In the emulsin from different preparations, Bull found 22 to 36 per cent. of ash, and in 100 parts of the substance calculated as free from ash, 42.1 to 43.7 carbon, 6.8 to 7.4 hydrogen, 11.4 to 11.6 nitrogen and 1.2 sulphur; he calculates the formula  $C_9H_9NO_6$ , or taking the sulphur into consideration,  $10 C_9H_9NO_6 + S$ . The dried brown emulsin dissolves with difficulty in water, leaving a residue which furnishes from 20 to 44 per cent of ash (phosphate of magnesia and phosphate of lime); the aqueous solution, upon the

earthy phosphates are dissolved out, and may be reprecipitated by neutralising the solution with ammonia. In sweet whey the earthy phosphates are wanting, whilst they exist in abundance in the acid whey. (Liebig, Poggendorff, und Wöhler's Handwörterb. der Chemie III, 229.)

(1) Ann. Chem. Pharm. LXIX, 145; Sill. Am. J. [2] VIII, 74.

(2) Arch. Pharm. [2] XI.V, 24, 129.

Emulsin.

addition of alcohol gives a precipitate, which when dried *in vacuo* remains white, even when it has not been washed with absolute alcohol. The aqueous solution of emulsin possesses in a high degree the property of inducing the decomposition of amygdalin into bitter almond-oil and hydrocyanic acid; the presence of foreign substances, even of alcohol and acetic acid, prevents this reaction. The property of being precipitated by alcohol does not belong to emulsin itself, but depends upon the presence of phosphates. When an emulsion of almonds was neutralised with lime-water and filtered, the filtrate distinctly exhibited the reaction with amygdalin, but was not precipitated by alcohol, and contained no phosphoric acid. Emulsin possesses a distinctly acid reaction. It is decomposed, but not coagulated by heat. Its solution becomes turbid at 35° or 36°, is milky at 45°, and between 85° and 90° deposits a snow-white granular precipitate containing from 49 to 59 per cent of ash, and amounting to 10 per cent of the emulsin employed; the solution after being boiled for some minutes, yields a filtrate which rapidly becomes opaque when heated to ebullition, and deposits a flocculent precipitate which redissolves on cooling. This filtrate contains two products of the decomposition of emulsin, of which one (amounting to about 25 per cent of the emulsin employed) is not precipitated by alcohol; the other (about 30 per cent) falls upon the addition of alcohol, as a white granular precipitate which contains 18 to 35 per cent of ash; and in the organic portion of the precipitate Bull found 42.5 to 43.1 per cent carbon, 6.7 to 7.0 hydrogen, 8.3 to 8.6 nitrogen, and 41.4 to 42.0 oxygen and sulphur; the aqueous solution of this substance gives with acetate of lead a precipitate containing sulphur, whilst a nitrogenised substance, free from sulphur, remains in solution. From a solution which has not been heated to ebullition the emulsin is entirely precipitated by acetate of lead, and the precipitate induces the formation of bitter almond-oil from amygdalin (as Orloff has already shown). A solution of emulsin after standing for four or five days at the ordinary temperature begins to decompose with evolution of gas; in this decomposition lactic acid is produced, the identity of which was proved by the analysis of the lime-salt. The same acid is formed in the absence of an emulsion of almonds; the formation of acetic acid was not observed in this process.

**Legumin.**—The precipitate produced by the addition of acetic acid to the aqueous solution of the almonds, before the precipitation of the emulsin (compare page 341), was washed with water and boiled with alcohol and ether; it then appeared as a fine reddish powder, which was not precipitated by alcohol from its alkaline solution, and did not dissolve in weak, and only partially in concentrated acetic acid; it contained 1.6 per cent of ash; the substance calculated as free from ash furnished 51.0 per cent carbon, 6.9 hydrogen, 15.8 and 16.8 nitrogen and 0.6 sulphur.

Löwenburg(1) has examined the legumin from peas and sweet almonds with the following results. The legumin prepared as usual from peas, when washed with cold water, is stated to be a mixture of legumin and albumin; but when the washing has been performed with hot water, it is a mixture of albumin with a product of the decomposition of legumin. In order to separate legumin from albumin, the mixture is dissolved in ammonia, the excess of the latter is expelled by evaporation, the solution mixed with chloride of sodium and heated to ebullition; the coagulum thus produced is separated by filtration, the filtrate precipitated by acetic acid, and the precipitate washed, first with cold water, and afterwards with boiling alcohol and ether. The legumin thus obtained (A) is insoluble in cold water, and when boiled is decomposed into a substance richer in carbon, soluble in water and insoluble in acetic acid (B), and into a substance containing less carbon than legumin, and insoluble in water (C). Legumin is precipitated by acetic acid, and redissolved by an excess of acid. Besides legumin and albumin, the infusion of peas contains another substance which is precipitated from it by acetic acid, and is not redissolved by an excess of the precipitant; this precipitate is soluble in pure water: its solution in ammonia, from which the excess of the latter has been evaporated, is partly precipitated by boiling with chloride of sodium.—The aqueous emulsion of sweet almonds also contains the above-mentioned substance soluble in water and insoluble in acetic acid; the legumin (A) prepared from this emulsion by the process above-described, resembles that obtained from infusion of peas in its behaviour with acetic acid and with boiling water; by treatment with the latter there are formed a substance (B) soluble, and another (C) insoluble in water. The ammoniacal solution of the emulsin from almonds, as well as the original emulsion, may be evaporated in air without rendering the emulsin insoluble (compare page 342), whilst during the evaporation of the infusion of peas part of the legumin is separated. Löwenburg determined the percentage composition of legumin and its products of decomposition; (D is a preparation obtained by removing the albumin from almond-emulsion by ebullition, filtering, precipitating the filtrate by acetic acid, and washing the precipitate, first with cold water, and afterwards with boiling alcohol and ether):

Legumin.

	From peas.				From almonds.					
	A.	B.	C.		A.	B.		C.		D.
Carbon .	53·9	54·7	50·3	51·1	51·1	51·7	52·0	50·3	51·6	50·2
Hydrogen .	7·2	7·1	6·8	7·4	7·2	7·1	7·1	6·9	7·7	7·0
Sulphur .	0·3									

Gelatin.

**Gelatin.**—Reinsch(1) has observed, under the microscope, what he believes to be a tendency of gelatin to crystallise.

**Action of Caustic Potassa upon Casein, Albumin and Fibrin.**—Bopp(2) has investigated the action of caustic potassa upon casein, albumin and fibrin, with a view to discover the most advantageous method of preparing leucine and tyrosine. He found that fused caustic potassa acts in exactly the same way upon the three substances in question. In order to obtain the greatest possible quantity of tyrosine (which, like leucine, is decomposed by too long boiling with caustic potassa), he recommends the following process. Dried casein, fibrin or albumin, as finely powdered as possible, is treated with an equal weight of hydrate of potassa fused in its combined water in a very capacious iron vessel, a little water being added from time to time to replace that which evaporates; ammonia and hydrogen of a peculiar odour (compare page 346) are evolved, and the mass becomes brown; as soon as the brown colour changes to yellow, the process is arrested by carefully pouring in a quantity of water; the solution is then saturated with acetic acid, filtered and allowed to cool. In a successful operation needles of tyrosine are now separated. The solution is evaporated till a crystalline pellicle forms on the surface, and after twenty-four hours, treated with strong spirit, which leaves the remainder of the tyrosine with some leucine undissolved; to the alcoholic solution, sulphuric acid diluted with spirit is now added as long as sulphate of potassa is separated, and after removing the spirit, the excess of sulphuric acid added is precipitated by means of acetate of lead; when the oxide of lead is removed by sulphuretted hydrogen, and the solution again evaporated, a fresh quantity of leucine is obtained. The tyrosine is freed from leucine by recrystallisation from water, and in order to deprive it of a brown impurity still adhering to it, it is dissolved in hydrochloric acid, the solution is decolorised with animal charcoal and mixed with a quantity of acetate of potassa corresponding to the hydrochloric acid; it may then be rapidly filtered and crystallised. Leucine is soluble to a considerable extent in water and alcohol if acetate of potassa be present, and hence, in its preparation, the potassa should be removed as far as possible by sulphuric acid. The leucine is freed from the last portions of tyrosine by dissolving it in so much hot water that only a little leucine, and with this the tyrosine, crystallises out; the solution is deprived of the last traces of tyrosine by addition of basic acetate of lead, or better, of hydrated oxide of lead, by which tyrosine, colouring matter, and some leucine are precipitated (pure solutions of tyrosine and leucine are not precipitated by basic acetate of lead), the lead is then removed by sulphuretted hydrogen, the leucine allowed to crystallise, decolorised with animal charcoal and recrystallised.—If the action of the fused hydrate of potassa upon the dry

(1) Jahrb. Pr. Pharm. XVIII, 191.

(2) Loc. cit. p. 340.

animal substance be interrupted as soon as the first violent action has subsided, as much leucine is formed as in the preceding process, but no tyrosine.

**Action of Hydrochloric or Sulphuric Acid upon Casein, Albumin and Fibrin.**—Leucine and tyrosine are also formed on boiling casein, albumin and fibrin, with 4 or 5 parts by weight of concentrated hydrochloric acid (at first, even when air is excluded, a violet tint appears, which with access of air passes into brown), or by boiling either of these substances for one day with 3 or 4 times its weight of hydrated sulphuric acid and 12 parts of water. It is best to dissolve the animal substance (the three substances mentioned above all behave in the same manner) in 4 or 5 times its weight of concentrated hydrochloric acid, and to evaporate in a water-bath with the addition of 3 or 4 parts of sulphuric acid; from the brown, pitchy, or syrupy mass thus obtained, the hydrochloric acid is expelled as far as possible, the brown mass treated with hot water, boiled for some time with an excess of milk of lime to expel the ammonia, and rapidly filtered through linen (in this manner also, the brown substance sparingly soluble in acids, and easily soluble in potassa, which Mulder believes to be humic acid, is separated), the filtrate still contains lime; the lime is separated by sulphuric acid; the excess of the latter by acetate of lead, and the lead by sulphuretted hydrogen; the solution is evaporated to a syrupy consistence, and after long standing, the leucine and tyrosine which crystallise out are separated from the syrup by means of alcohol of 86 per cent, in which the syrupy portion is soluble; the leucine and tyrosine are then separated as in the process just described. The syrup which dissolves in the spirit still contains some leucine; after standing for some months, groups of crystals separate from this syrup, and may be freed from the surrounding liquid by rapid stirring with cold water; these crystals consist of leaflets of leucine, and needles of a peculiar substance, which is distinguished from leucine by its difficult solubility in water, from tyrosine by its property of subliming, and from both by its easy solubility in absolute alcohol and almost perfect insolubility in hydrochloric acid and potassa; it was obtained in too small a quantity to allow of an accurate examination.

**Putrefaction of Casein, Albumin and Fibrin.**—Even in putrefaction, casein, albumin and fibrin exhibit in all essential points a similar behaviour; in contact with 40 or 50 parts by weight of water at 20° or a somewhat higher temperature, the animal substance entirely disappears, forming a turbid liquid. (Fibrin dissolves in a few days, forming a liquid which, although partly composed of the products of decomposition to be presently mentioned, is coagulable by heat like a solution of albumin; compare page 339).—In order to isolate the products of decomposition, the turbid liquid is mixed with milk of lime, filtered through linen, and the filtrate, after the addition of

Action of hydrochloric or sulphuric acid upon casein, albumin and fibrin.

Putrefac-  
tion of  
casein,  
albumin  
and fibrin.

some more milk of lime, is subjected to distillation. The distillate has the same intense odour which is produced by the action of caustic potassa upon the animal substance (page 344); it is concentrated by several rectifications, and finally distilled with the addition of an excess of phosphoric acid to separate the ammonia, when crystalline leaflets are observable in the condensing tube, and a turbid distillate passes over, from which ether completely separates the odorous substance; the ethereal solution, on evaporation, leaves a crystalline substance of a powerfully offensive odour, which is coloured red by hydrochloric or dilute sulphuric acid, and is decomposed into oily drops, which, when treated with potassa, assume a different and less powerful odour.—The residue from this distillation is carefully freed from lime by the addition of the smallest possible excess of sulphuric acid mixed with water, so that the liberated acids (valeric, butyric, &c.) remain in solution, the liquid is then filtered and distilled; the liquid remaining in the retort is precipitated with acetate of lead; the pasty precipitate thus produced, when dried, powdered, suspended in water and decomposed by sulphuretted hydrogen, yields a liquid which, on evaporation, deposits brown-red droplets of an oily acid (in one case benzoic acid appeared to be present). The solution separated from the lead-precipitate is freed from lead by sulphuretted hydrogen, and evaporated to a syrup, from which crystals of leucine are speedily deposited; the syrupy mass dissolves in alcohol with separation of leucine. From the residue left on evaporating the alcoholic solution, absolute alcohol extracts a peculiar substance; on agitating this alcoholic solution with ether (when the latter takes up fatty matter and some of the above-mentioned oily acid), this substance is precipitated in an impure state as a slimy mass, which is acid to the taste and capable of dissolving lime, baryta, protoxide of lead, &c.; when treated with hydrochloric or sulphuric acid, this substance assumes a brown colour, and furnishes tyrosine.

**Leucine.**—If to an aqueous solution of pure leucine a little fibrin be added, and the liquid allowed to remain in a warm situation, putrefaction takes place, the leucine disappears, and valeric acid is formed.

It was announced in the last Annual Report (II, page 138), that Gerhardt and Laurent, as well as Cahours, have assigned to leucine the formula  $C_{12}H_{13}NO_4$ . Mulder(1) still maintains that the true formula of leucine is  $C_{12}H_{12}NO_4$ ; new analyses, like those which he made at an earlier period, have given results coinciding with this formula, and even a fresh analysis of the combination of leucine with nitric acid corresponded with the formula  $C_{12}H_{12}NO_4, HO, NO_5$ .—

(1) Scheik. Onderzoek. V, 4. Stuk, 271; J. Pharm. [3] XVII, 49. Gerhardt's remarks thereupon Laur. u. Gerh. C. R. 1850, 64; J. Pharm. [3] XVII, 134.

Strecker(1) is of opinion that the difference in Mulder's formula arises from the contamination of the leucine with a substance which obstinately adheres to it, and is only removed by repeated treatment with warm alcohol; in the compound (dried over sulphuric acid) which was obtained by mixing a boiling solution of leucine with acetate of lead, and cautiously adding ammonia, he found 12 equivs. of carbon for 1 equiv. of protoxide of lead; for the pure leucine dried at 100° he obtained the formula  $C_{12}H_{13}NO_4$ .

**Tyrosine. (Decomposition of the Horn of Oxen by Sulphuric Acid or Caustic Potassa.)**—Hinterberger(2) has examined the horn of oxen, and has found that tyrosine is one of the chief products of decomposition. Fine shavings of the inner layer of the horn of an ox were boiled out with ether and alcohol, and the finer portion afterwards separated by lixiviation with water. The shavings thus treated (dried at 100°) contained 1·9 per cent of ash (chloride of magnesium, chloride of sodium, phosphate of lime, sesquioxide of iron and silica), and the substance (calculated as free from ash?) 50·46 and 50·83 per cent carbon, 6·65 and 6·68 hydrogen, 16·23 nitrogen, and besides oxygen, a quantity of sulphur which was not determined. By the action of boiling diluted sulphuric acid upon horn, tyrosine and leucine are formed:  $\frac{1}{2}$  lb. of horn shavings was boiled for thirty-six hours with a mixture of 2 lbs. of concentrated sulphuric acid, and 6 lbs. of water, the evaporated water being from time to time replaced; freshly prepared milk of lime was then added till the reaction became strongly alkaline, the precipitate thus formed was boiled for twenty-four hours with the liquid, filtered through linen, and the residue pressed. The filtrate was heated to boiling, diluted sulphuric acid was added until the filtrate was feebly acid; after the sulphuric acid was removed from the filtrate by a mixture of neutral and basic acetates of lead, the excess of lead was separated by sulphuretted hydrogen, and the filtrate evaporated till a crystalline pellicle formed. The crystals which had separated from the solution after twelve hours were washed with alcohol of 86 per cent, and with a little water, boiled with a little potassa, carbonate of potassa and water; after this they were filtered, the filtrate was mixed with excess of acetic acid and allowed to crystallise, the crystals being finally purified by treatment with animal charcoal and recrystallisation. These crystals exhibited the reactions of the tyrosine obtained from casein by Liebig(3), and from cochineal by Warren De La Rue(4), who described it as a crystalline substance identical with tyrosine; Hinterberger found (for the substance dried at 100°) the same composition as Warren De La Rue,  $C_{18}H_{11}NO_6$ .—After the horn was boiled with sulphuric acid, if the acid was precipitated as above by milk of lime,

(1) Ann. Ch. Pharm. LXXII, 89.

(2) Ann. Ch. Pharm. LXXI, 70.

(3) Ann. Ch. Pharm. LVII, 127.

(4) Annual Report for 1847 and 1848, II, 95.



Tyrosine.  
(Decomposition of the horn of oxen by sulphuric acid or caustic potassa.)

boiled, and the excess of lime accurately removed by sulphuric acid, a little leucine was found in the solution together with tyrosine. The quantity of tyrosine and leucine obtained from horn by this process increases up to a certain limit with the duration of the ebullition with sulphuric acid, and, possibly, even with that of the action of milk of lime upon the sulphuric acid solution.—By fusing the horn-shavings with an equal weight of hydrate of potassa until free hydrogen is evolved, together with the ammonia, and the brown colour of the mixture has become somewhat brighter, tyrosine and leucine are also formed, and after dissolving the mass in boiling water, supersaturating with acetic acid, filtering and evaporating, they may be obtained in crystals; if the mass dissolved in water be supersaturated with sulphuric acid and subjected to distillation, the distillate contains, together with a neutral substance having a foecal odour, acetic acid, and some butyric and valeric acids.

The formula  $C_{18}H_{11}NO_6$  for tyrosine is confirmed by Strecker's(1) experiments upon the action of nitric acid on this substance. Tyrosine dissolves with a yellow colour in ordinary nitric acid; red fumes are soon evolved, and a yellow crystalline powder separates; if the solution be evaporated there remain crystals of pure oxalic acid, which is moreover the sole product of the action of boiling nitric acid upon tyrosine. If tyrosine be diffused through water and nitric acid be added drop by drop, it dissolves, and on further addition of nitric acid a yellow colour is produced without evolution of gas. If the addition of nitric acid is discontinued as soon as the liquid has assumed a yellow colour, and the mixture set aside, there separates, after several hours (more rapidly if the sides of the vessel be rubbed with a glass rod), a yellow powder similar to that mentioned above. This yellow substance dissolves with difficulty in cold water, more easily in boiling water, and crystallises from this solution, on cooling, in small brown, almost bronze-coloured scales, which yield a yellow powder; it is less easily soluble in alcohol than in water; the solutions have a yellowish colour and an acid reaction. The composition of this substance is  $C_{18}H_{11}N_3O_{16} = C_{18}H_{10}(NO_4)NO_6, HO, NO_5$ , *i. e.*, nitrate of nitrotyrosine; it gives, with sulphuric acid and sulphate of iron, the reaction of nitric acid; sulphuric acid converts it into sulphate of nitrotyrosine. The nitrate of nitrotyrosine dissolves with an intense red colour in ammonia and in potassa; on adding nitrate of silver to the solution of nitrate of nitrotyrosine in dilute ammonia, there is produced, in the cold, an amorphous yellow precipitate which, on boiling, becomes of an intense red, or with an excess of ammonia, of a sooty-brown colour; this precipitate is soluble in ammonia and in nitric acid, deflagrates slightly when heated, and has (when dried over sulphuric acid) the composition  $C_{36}H_{17}N_4O_{20}Ag_3 = 2(C_{18}H_{10}(NO_4)NO_6) +$

(1) Ann. Ch. Pharm. LXXIII, 70; Chem. Gaz. 1850, 153; J. Pharm. [3] XVII, 395.

3 AgO—3 HO. By decomposing this silver-compound with hydrochloric acid, yellow needle-like crystals of hydrochlorate of nitrotyrosine are obtained; by treating the silver-compound suspended in water with sulphuretted hydrogen, a solution is formed, which on evaporation furnishes bright yellow microscopic stellated groups of needles (nitrotyrosine); (these last did not give the reaction of nitric acid when tested with sulphate of iron and sulphuric acid).

Tyrosine.  
(Decomposition of the horn of oxen by sulphuric acid or caustic potassa.)

**Oxidation of Casein, Albumin, Fibrin, Gelatin and Organic Compounds generally.**—Liebig(1) has published some remarks upon the oxidation of organic compounds. He founds these upon the observation of Schlieper and Guckelberger(2), that in the oxidation of gelatin, casein, albumin, and fibrin, a nitrogenised substance (valeronitrile), free from oxygen, is formed. He directs attention to the circumstance, that according to Bopp's experiments (compare page 344) two nitrogenised substances, tyrosine and leucine, are formed from fibrin, albumin and casein by the action either of acids or alkalis at a high temperature, whilst gelatin under similar conditions furnishes leucine and glycocine; moreover, leucine and tyrosine are products of the putrefaction of albumin, fibrin and casein. The constant production of these substances in three so different processes of decomposition, would lead us to suppose that albumin, fibrin and casein are conjugate compounds which contain, amongst other substances, the conjuncts leucine and tyrosine; in a similar manner glycocine, or a substance capable of yielding glycocine by the assimilation of the elements of water, appears to play the part of a conjunct in gelatin. Most of the other substances produced from the animal matters in question, either by the action of acids and alkalis, or by putrefaction, are non-nitrogenised substances, organic acids of the series  $C_nH_nO_4$ , especially butyric acid. Among the non-nitrogenised products of the oxidation of animal matters Guckelberger obtained, although under somewhat different circumstances, likewise these acids, together with varying proportions of the corresponding aldehydes, and bitter-almond oil; the nitrogenised bodies obtained were hydrocyanic acid and valeronitrile; the residue of the distillation of the animal matter with sulphuric acid and binoxide of manganese contained neither leucine nor tyrosine. If we consider them as conjugate compounds, albumin, fibrin, and casein become the types of a group of nitrogenised compounds, the members of which are distinguished by a readiness, on the accession of oxygen and the elements of water, to split up into ammonia, leucine and tyrosine (or glycocine in the case of gelatin), or into ammonia, hydrocyanic acid, valeronitrile and organic acids or their aldehydes. The substances mentioned are formed in a mixture containing binoxide of manganese, or chromate

(1) Ann. Ch. Pharm. LXX, 311.

(2) Comp. Annual Report for 1847 and 1848, II, 138.

Oxidation  
of casein,  
albumin,  
fibrin,  
gelatin  
and organic  
compounds  
generally.

of potassa and free sulphuric acid; we may therefore suppose that the process of oxidation is preceded by another change in which under the influence of the acid, the albumin, fibrin, casein and gelatin are split into ammonia, leucine, tyrosine and glycocine on the one hand, and non-nitrogenised bodies on the other, just as when no oxidising agent is present. According to these views, valeronitrile and hydrocyanic acid would be secondary products of the action of the acid, in presence of oxygen, upon leucine, tyrosine or glycocine. In fact, leucine, when distilled with dilute sulphuric acid and binoxide of manganese, yields valeronitrile and carbonic acid; if more concentrated acid be employed, the distillate has an acid reaction due to valeric acid, and the residue contains ammonia. Hence leucine is split up, on accession of oxygen, into valeronitrile, carbonic acid and water. Glycocine is decomposed by dilute sulphuric acid and binoxide of manganese, into hydrocyanic acid (the nitrile of formic acid), carbonic acid and water. When distilled with binoxide of lead alone, leucine furnishes only traces of valeronitrile, but it gives a considerable quantity of the aldehyde of butyric acid(1) discovered by Guckelberger, and, lastly, ammonia.—With regard to the non-nitrogenised products of the oxidation of the animal matters under consideration, Liebig does not think that each arises from a different conjunct. The various acids of the series  $C_nH_nO_4$ , and the compounds derived from them (the aldehydes, for example) are formed, according to Liebig, from one another, those with the smaller number of carbon-equivalents being formed from those richer in carbon by oxidation. This conversion might be effected by simple assimilation of oxygen, thus for example,  $C_{16}H_{16}O_4 + O_4$  may become  $2 C_8H_8O_4$ ;  $C_8H_8O_4 + O_4$  may be converted into  $2 C_4H_4O_4$ , and so forth; this view, however, is not supported by facts. It is more probable that the various acids of the series  $C_nH_nO_4$ , are produced by a process analogous to that of oxidation by electrolysis, studied by Kolbe (page 230), according to which an acid is split up, on accession of oxygen, into carbonic acid, which contains all the oxygen of the acid, and a hydrocarbon which contains its hydrogen; by the subsequent oxidation of this hydrocarbon, an oxide, or a hydrate of the oxide is formed, and this last is converted by separation of a part of its hydrogen into an aldehyde, or by farther oxidation into an acid containing a smaller number of carbon-equivalents than the original one, which may undergo the same kind of change as its predecessor.

**Action of Nitric Acid upon Animal Substances.**—Van der Pant(2), under Mulder's direction, has examined the product of the action of nitric acid upon animal substances, which Mulder(3) had designated *xanthoproteic acid*. In the subjoined abstract, we can only give

(1) Comp. Annual Report for 1847 and 1848, II, 140.

(2) Scheikund. Onderzoek. V, 2. Stuk, 136; Chem. Gaz. 1849, 253.

(3) Berzelius' Jahresber. XIX, 651.

the mean results of Van der Pant's numerous analyses. Finely-powdered coagulated white of egg was exposed for 168 hours, to the action of a mixture of 2 parts of water, and 1 part of commercial nitric acid, the residue washed, and freed from fat by treatment with ether; when dried, first in the air, and then in a finely-powdered state, at  $130^{\circ}$ , it had the composition A (the acids to be presently described were dried in the same manner). This yellow acid dissolved in ammonia, forming a dark-brown solution; when the residue left on evaporating this solution was dried at  $130^{\circ}$ , all the ammonia was expelled, and xanthoproteic acid (B) remained. The residue obtained by evaporating the ammoniacal solution was treated with excess of baryta-water, the excess of baryta was removed by carbonic acid, and the chesnut-coloured solution evaporated; the baryta-salt thus obtained (when dried at  $130^{\circ}$ ), contained 13.1 per cent of baryta, together with an organic substance of the composition C. The solution of the above-mentioned ammonia-salt, evaporated to dryness and redissolved, gave with acetate of copper a green precipitate, which, when dried at  $100^{\circ}$ , contained 12.9 per cent of oxide of copper, together with an organic substance of the composition D.—Cow-horn was treated for 48 hours with the above dilute acid; the residue, together with the substance separated from the solution upon addition of water, was treated with ether, and dried; the product had sometimes a pure yellow, sometimes a brownish-yellow tint, and exhibited the composition E; after treatment with ammonia and drying at  $130^{\circ}$ , it had the composition F; the solution of the ammonia-salt gave with neutral acetate of lead a yellow precipitate, which became brownish-yellow when dried at  $130^{\circ}$ , and contained 14.1 per cent of oxide of lead, together with an organic substance of the composition G.—From horses' hoofs, in the same manner, a product of the composition H was obtained.—Fibrin from ox-blood treated for 96 hours with the above acid, and the farther process conducted as in the other cases, gave a brown product of the composition I.—The inner portion of an old cheese was treated for 48 hours with a mixture of  $1\frac{1}{2}$  parts of ordinary nitric acid and 2 parts of water; the product was well washed with water, boiled once with ether, and thrice with alcohol; it had the composition K.—Sheeps'-wool treated with the dilute acid for 28 hours, and subsequently submitted to the above process, furnished a product indicated in the table by L; horse-hair treated for 14 hours with similar acid, yielded a substance having the composition M.—The so-called protein from white of egg (obtained by dissolving the white of egg in very dilute potassa, adding sulphurous acid till the reaction of sulphur was no longer obtained by acetate of lead, filtering, precipitating with acetic acid, washing the precipitate, and separating the fat with ether) gave, after treatment for 14 hours with a mixture of 1 part of nitric acid and 3 of water, a product of the composition N, and this, by the above process, yielded a baryta-salt

Action of  
nitric acid  
upon  
animal  
sub-  
stances.

Action of  
nitric acid  
upon  
animal  
sub-  
stances.

containing (when dried at  $130^{\circ}$ ) 12.7 per cent of baryta, and an organic substance of the composition O.—The so-called protein prepared from horn (by a similar process to that employed for white of egg), after treatment for 48 hours with 1 part of nitric acid and 2 parts of water, gave a product from which, by neutralising with ammonia, treatment of the solution with an excess of milk of lime, filtering, evaporating to a syrupy consistence, redissolving this syrup, and after filtration precipitating with acetate of lead, a lead-salt was prepared, which (dried at  $130^{\circ}$ ) contained 14.0 per cent of lead, together with an organic substance of the composition P; that portion of the horn which remained undissolved after treatment with potassa, was again treated for protein, and this, after digestion for 40 hours with 1 part of nitric acid and 3 parts of water, and so forth, furnished a residue of the composition Q.

	A.	B.	C.	D.	E.	F.	G.	H.	I.	K.	L.	M.	N.	O.	P.	Q.
Carbon	50.3	50.5	52.0	52.7	50.1	50.0	49.7	49.5	49.3	50.7	49.4	49.2	50.9	51.8	49.9	50.6
Hydrogen	6.4	6.3	6.2	6.4	6.2	6.5	6.5	6.5	6.2	6.3	6.4	6.0	6.6	5.9	6.2	6.4
Nitrogen	14.8	15.2	14.5	14.2	14.8	15.2	14.7	14.1	14.8	14.4	14.5	14.7	14.8	14.5	14.5	14.7
Oxygen	27.3	27.2	27.3	26.7	27.2	27.3	29.1	28.4	28.3	27.8	28.7	28.0	26.2	27.3	29.3	28.2
Sulphur	1.1															
Ash	0.1				0.1			0.2	0.4	0.2	0.1					

In an appendix to Van der Pant's paper Mulder sets forth the following conclusions. All the so-called protein-compounds, when acted upon by nitric acid, furnish one and the same substance. Xanthoproteic acid is a compound of nitrous acid with protein, and when  $S_2O_2$  is combined with the protein(1), it is also found in the resulting acid. The formula of xanthoproteic acid is  $2C_{36}H_{27}N_4O_{12} + NO_3$ , and the formula proposed by Mulder at an earlier period ( $C_{34}H_{26}N_4O_{14}$ ) must be altered to this. When this acid is produced by the action of nitric acid upon compounds of protein-sulphamide(2) the sulphamide is decomposed into  $S_2O_2$  which enters into the composition of the product. Xanthoproteic acid is a hydrate, and its water is capable of being replaced by bases; the acid, supposed to be free from water, has the formula  $2C_{36}H_{26}N_4O_{11} + NO_3$ . It loses  $NO_3$  when acted upon by chlorine.—In conclusion, Mulder states his opinion, that since protein is capable of combining with  $ClO_3$  and with  $2ClO_3$ , and that even xanthoproteic acid is capable of combining with  $ClO_3$ , the empirical formula of protein may be considered as surely established as the nature of an empirical formula will in general permit.

**Products of the Oxidation of Vegetable Fibrin.**—As a contribution towards the proof of the identity of sulphurised and nitrogenised

(1) With regard to this view of Mulder's, comp. the Annual Report for 1847 and 1848, II, 129.

(2) Compare *ibid*.

animal matters with those of vegetable origin, F. Keller(1) has published some experiments upon the oxidation of vegetable fibrin by means of sulphuric acid and binoxide of manganese. Fresh gluten of wheat was added to about 2 lbs. of concentrated sulphuric acid, as long as it dissolved without blackening, so much water was then added that the solution still remained clear, and the mixture was subjected to distillation, in a capacious retort, with the addition of 2½ to 3 lbs. of binoxide of manganese. The crude distillate was saturated with carbonate of lime, and the solution distilled; lime-salts remained in the residue, and a liquid containing aldehydes passed over.—The lime-salts, by decomposition with carbonate of soda, were converted into soda-salts, and these last were distilled with sulphuric acid. For the separation of the acids in the distillate (upon which there swam a thin oily layer, which disappeared on addition of much water), Keller employed the method described at page 227; he saturated  $\frac{1}{10}$ th of the acid mixture with soda, and distilled, saturated the same proportion of the distillate, and repeated the operation, and so forth. In the first residue formic acid remained; it existed also in the second; then in turn acetic acid, propionic acid, valeric, and lastly remained butyric acid (sometimes also mixtures of two neighbouring acids were obtained); all the acids were identified, at least by the determination of the atomic weight from the silver-salt, and, in most cases, even by ultimate analysis.—The distillate containing aldehyde yielded a resin when treated with concentrated solution of potassa, and gave, with a silver solution, a mirror of silver. It soon became acid in the air. In order to separate it as far as possible from water, it was repeatedly rectified; in the water which remained behind, there appeared oily drops possessing the odour of bitter-almond oil. By a fractional distillation there passed over between 23° and 60°, chiefly the aldehyde of acetic acid,  $C_4H_4O_2$ ; between 60° and 80° a liquid was obtained exhibiting the properties which Guckelberger(2) ascribed to the so-called aldehyde of propionic acid (in contact with platinum-black, however, this liquid formed no acid); between 80° and 120°, aldehyde of valeric acid ( $C_{10}H_{10}O_2$ ) passed over (this formed with ammonia a crystalline compound  $C_{10}H_{10}O_2, NH_3$ , and in contact with platinum-black, valeric acid); in the residue at 120°, there remained bitter-almond oil  $C_{14}H_6O_2$ .—Thus the similarity of the products of decomposition of vegetable fibrin, to those of animal fibrin, casein and albumin(3) under the influence of sulphuric acid and binoxide of manganese has been clearly demonstrated.

Products  
of the  
oxidation  
of vegeta-  
ble fibrin.

(1) Ann. Ch. Pharm. LXXII, 24.

(2) Annual Report for 1847 and 1848, II. 138.

(3) Comp. Annual Report for 1847 and 1848, II. 138.

**Allantoin.**

**Allantoin.**—Dauber(1) has determined the crystalline form of allantoin. The crystals belong to the monoclinometric system,  $\infty P. \infty P \infty. 0 P. + P \infty; \infty P : \infty P$  in the clinodiagonal principal section =  $65^{\circ} 27'$ ;  $0 P : \infty P = 88^{\circ} 14'$ ;  $+ P \infty : \infty P = 69^{\circ} 17'$ ; inclination of the clinodiagonal to the principal axis =  $86^{\circ} 43'$ ; clinodiagonal : orthodiagonal : principal axis =  $1.0860 : 0.6968 : 1$ . Cleavage takes place parallel to  $+ P \infty$ .

Wöhler(2) finds that calf's urine always contains allantoin, and, indeed, in such quantity (a bladder full of urine containing several grammes), that it will conveniently serve as a source from which to prepare this substance. The urine is evaporated to the consistence of a thin syrup at a temperature below that of ebullition; after standing for several days, the allantoin crystallises out mixed with much phosphate of magnesia (free from ammonia), and an amorphous body which consists chiefly of urate of magnesia. The diluted mother-liquor is poured off together with the suspended amorphous substance, the crystals are washed with cold water, and dissolved in a small quantity of boiling water. The solution thus produced is treated with blood-charcoal, filtered whilst boiling hot, and mixed with a few drops of hydrochloric acid to prevent the separation of phosphate of magnesia; on cooling, colourless allantoin crystallises out. The identity of the allantoin thus prepared with that obtained from the allantoic liquid, or by the oxidation of uric acid, was shown by the analysis of the crystals, and of the silver-compound ( $\text{AgO}, \text{C}_8\text{H}_5\text{N}_4\text{O}_5$ ). The allantoin prepared from calf's urine crystallises differently (in fascicular groups of thin crystals) to ordinary allantoin; it owes this property to the presence of a scarcely perceptible quantity of a foreign substance, which may be removed by combining the allantoin with oxide of silver; the allantoin separated from this compound crystallises in the usual form.

**Animal Chemistry. Constituents of the Egg.**—We have already mentioned (compare Annual Report for 1847 and 1848, II, p. 147) that milk-sugar is said to be contained in the white of hens' eggs. According to Aldridge(3) if white of hens' eggs be diffused through alcohol of 0.85 sp. gr., the mixture heated to coagulation, filtered,

(1) Ann. Ch. Pharm. LXXI, 68.

(2) Ann. Ch. Pharm. LXX. 229; Instit. 1849, 308; Compt. Rend. XXIX, 9 (in abstr.); Instit. 1849, 228.

(3) From the Medical Times in J. Pharm. [3] XV, 366; Ann. Ch. Pharm. LXXII, 319.

the alkaline filtrate evaporated, and the residue extracted with strong alcohol, the alcoholic solution yields after concentration, granular crystals of grape-sugar.—Barreswil(1) has determined the presence of sugar in white of egg (which he likewise extracted with alcohol), by the reaction with the alkaline potassa-tartrate of oxide of copper, as well as by fermentation and collecting the alcohol formed, but he could not succeed in obtaining crystals of grape-sugar. Moreover, his experiments have proved that the white of egg owes its alkaline reaction to carbonate of soda; that the yolk contains little or no alkali, and that its emulsive character is to be ascribed, not to the presence of alkali, but of a substance analogous to the pancreatic juice. Barreswil also states that the yolk of egg is not acid, but only becomes so in consequence of decomposition, and that the alkali and the sugar in the white of egg are capable of disappearing in the same proportion; he has farther shown that white of egg and similar substances are the more rapidly decomposed, the more largely they are diluted, above all when they happen to be placed in such circumstances as are most favourable to the solution of the ferment.

H. Rose(2) has published the analyses made by Poleck according to his method,(3) of the ashes of the white and yolk of hens' eggs. The aqueous extract of the carbonised substance left, in the case of the white of egg, 1·5013, in that of the yolk 1·048 grms. of residue of the percentage-composition A; the hydrochloric solution, obtained from the white, left 0·2835, that from the yolk, 0·206 grms. of residue of the composition B; in the case of the white, the coal after extraction with water and hydrochloric acid, yielded (besides some sand separated from the ash) only 0·0418, whilst in that of the yolk, 1·3052 grms. of ash were obtained, of the composition C. From these data, Rose calculates the composition of the entire ash, as stated at D.—In other analyses, the whole of which has not been published, great differences were observed in the composition and proportions of the individual constituents of the ash.—In hard-boiled eggs the proportion of the white to the yolk was found to be 60·6 to 39·4 and 58·4 to 41·6.

(1) J. Pharm. [3] XVII, 114. The conclusions Compt. Rend. XXVIII, 761.

(2) Pogg. Ann. LXXVI, 393; J. Pr. Chem. XLVIII, 60; Phil. Mag. [3] XXXV, 281.

(3) Annual Report for 1847 and 1848, II, 238; comp. the present Annual Report upon Analytical Chemistry.



Constituents of the egg.

	White of egg.				Yolk of egg.			
	A.	B.	C.	D.	A.	B.	C.	D.
Chloride of potassium .	51.33	—	—	25.67	—	—	—	—
„ sodium .	17.13	—	—	8.57	—	—	—	—
Potassa .	—	4.95	16.76	5.43	9.77	—	7.96	5.94
Soda .	17.71	9.13	5.48	12.49	7.65	—	6.75	4.82
Lime .	—	10.53	8.21	6.25	11.80	22.32	13.04	15.79
Magnesia .	—	11.61	9.02	7.03	2.04	2.98	2.04	2.36
Sesquioxide of iron .	—	2.75	5.64	2.09	0.95	3.71	0.99	1.85
Phosphoric acid .	—	23.85	37.24	15.28	68.74	70.97	64.13	68.26
Sulphuric acid .	1.67	—	—	4.84	—	—	—	—
Carbonic acid .	10.49	—	—	9.01	—	—	—	—
Silica .	—	10.56	17.63	7.05	—	—	2.76	0.92
Carbonate of lime .	—	11.14	—	—	—	—	—	—
„ magnesia .	—	15.48	—	—	—	—	—	—

Desor(1) adduces physiological reasons for regarding the liquid which surrounds the yolk in the ovarian eggs of the lower animals (especially in those of the *Ascidia rustica*) as a different substance from albumin, and proposes to assign to it the name *Biogen*.

**Respiration.**—Regnault and Reiset have now completed the description of their extended and ingenious researches upon the respiration of animals. Several preliminary communications on this subject have been already noticed in the preceding Annual Report (II, p. 148) (2). Their treatise contains a historico-critical account of the earlier researches upon this subject, and an accurate description of the apparatus in which the animals were allowed to breathe (the principle of this apparatus, which cannot be fully described without drawings, is noticed in the last Annual Report, II, p. 148); they have also described the apparatus, methods, and calculations, which they made use of in the analysis of the gases (compare the Report upon Analytical Chemistry). In each case the results of their experiments upon different animals and under different circumstances, are minutely detailed; these experiments are so numerous that our space will not allow us to enter here even into a cursory examination of them (the special results of several experiments were mentioned in the last Annual Report, II, p. 149), and we must, therefore, limit ourselves to the consideration of the general conclusions at which Regnault and Reiset have arrived.

In warm-blooded animals (mammalia and birds) living in their natural state, and on their proper food, an evolution of nitrogen is constantly taking place; the quantity of the nitrogen thus evolved is always less than 2 per cent, and in most cases less than 1 per cent

(1) Sill. Am. J. [2] VII, 395.

(2) Ann. Ch. Phys. [3] XXVI, 299; Ann. Ch. Pharm. LXXIII, 92, 129, 257. The conclusions J. Pharm. [3] XVI, 297

of the total weight of the oxygen consumed. When suffering from hunger the animals, on the contrary, frequently absorb nitrogen, and, indeed, in the same proportion in which, under ordinary circumstances, it is evolved; this absorption of nitrogen was almost always observed in hungering birds, but seldom in the mammalia. If, after several days' fasting, an animal be fed with food very different from that on which it usually subsists, it often still continues to absorb nitrogen; as soon as it has become accustomed to this diet, evolution of nitrogen again takes place (this was observed in hens which fasted for several days, and were then fed exclusively upon flesh). An evolution of nitrogen was also observed in sick animals.—The proportion between the oxygen contained in the expired carbonic acid, and the total amount of oxygen consumed, appears to depend much more upon the food than upon the species of the animal. It is very nearly 1 to 1, that is, the maximum quantity of oxygen is contained in the expired carbonic acid, when the animal is fed with grain (it was even frequently observed, in a hen and a rabbit, that the oxygen contained in the expired carbonic acid, exceeded the total amount of oxygen consumed); these quantities are in the ratio of 0.62 or 0.80 to 1 when the animal is fed on flesh alone; an intermediate ratio is observed when the food consists of green vegetables. The proportion between the inspired oxygen, and that expired in the form of carbonic acid, is nearly constant for animals of the same species, maintained on exactly the same diet. When the animal is under the influence of hunger, the proportion is nearly the same as it is when on a flesh diet, in general even somewhat less; in fact, when hungry, the animal is consuming the substance of its own body, *i. e.* flesh, and in this state all warm-blooded animals resemble, with respect to respiration, the carnivorous species. Hence the proportion between the oxygen contained in the expired carbonic acid, and the total amount of oxygen consumed, is by no means constant, since it was found to vary between 0.62 and 1.04.—The heat is undoubtedly developed in animal bodies by a purely chemical process, but of a nature too complicated to allow the quantity of heat produced to be calculated from that of the oxygen consumed. It happens only by chance, when the quantity of heat evolved by an animal body, is found nearly to coincide with that which would result from the combustion of the carbon contained in the expired carbonic acid, and of so much hydrogen as would suffice to form water with that portion of the inspired oxygen which is not contained in the carbonic acid; the earlier determinations of the quantity of the expired carbonic acid are probably too low, moreover the foundation of the above assumption is invalidated by the observation that more oxygen was frequently contained in the expired carbonic acid, than was consumed by the animal.—The quantity of oxygen consumed, which corresponds to a given period and a given weight of the animal, varies with the

Respira-  
tion.

duration of the process of digestion, with the amount of exercise, and a variety of other circumstances; for the same species, it is greater in young than in old animals; it is greater in thin but yet healthy animals, than in those which are fat. Lastly, the quantity of oxygen consumed varies, even in animals of the same species, according to their absolute weight; it is ten times greater in sparrows than in hens.—Warm-blooded animals evolve, by perspiration, only small, and scarcely estimable quantities, of ammonia and gases containing sulphur.

During the *winter-sleep of hibernating animals* (e. g. marmots) nitrogen is frequently absorbed; the proportion borne by the oxygen contained in the expired carbonic acid to the total amount of oxygen consumed, is frequently only as 0.4 to 1. Since the quantity of inspired oxygen, which is not converted into gaseous compounds, is here greater than that of the expired carbonic acid, and since the animal, at its diminished temperature, during hybernation, evolves less water by perspiration, the mere process of respiration produces under these circumstances an increase of weight of the body; this increase, however, is limited to the intervals between which the animal passes its urine. During the winter-sleep the marmots require far less (frequently only  $\frac{1}{30}$ th) oxygen than in their waking condition; immediately upon waking, however, they require, in consequence of their accelerated respiration, much more than in their ordinary waking condition. In its torpid state a marmot may remain for a long time, without injury, in an atmosphere so poor in oxygen that a waking marmot would be immediately suffocated in it.

With respect to the respiration of cold-blooded animals, Regnault and Reiset found that reptiles of the same weight consume much less oxygen than warm-blooded animals, but that no perceptible difference exists with regard to the nature and proportions of the absorbed and evolved gases; the experiments showed at one time a slight absorption, at another a slight evolution of nitrogen.—Frogs which had been deprived of their lungs, breathed with the same rapidity as in an uninjured state, and no essential difference was observed in the proportions of the absorbed and evolved gases.—The respiration of earth-worms resembles that of frogs in respect of the amount of oxygen consumed for the same weight of the body, and the proportion between the total amount of oxygen consumed, and that contained in the expired carbonic acid.—The respiration of insects (may-bugs and silk-worms) is far more rapid than that of reptiles, and they consume, in proportion to their weight, almost as much oxygen as the mammalia. The circumstance that only a slight elevation of the temperature of their bodies is thereby produced, depends upon the great relative surface of the insects; a thermometer surrounded with may-bugs indicated a temperature  $2^{\circ}$  above that of the surrounding air.

When animals of either class respire in air containing twice or three times as much oxygen as ordinary atmospheric air, no change is observed in the proportion of the expired gases; the consumption of oxygen remains the same, the same proportion is maintained between the oxygen consumed and that contained in the expired carbonic acid, and the same amount of nitrogen is evolved. When the respiration is carried on in air the nitrogen of which is in great part replaced by hydrogen, very little change takes place; a somewhat increased consumption of oxygen is observed, probably to compensate for the greater loss of heat in air containing hydrogen.

Scharling(1), in an appendix to a previous investigation(2), has brought forward some experiments upon human respiration, by which he found that in violent bodily exercise about three times as much carbonic acid was expired as in a state of rest; according to him habitual drunkards expire less carbonic acid than other men. He has also communicated some very inadequate experiments made with a view to measure, by comparison with the quantity furnished by other sources of heat, the quantity of heat evolved by the respiratory process, and to determine how much of the heat evolved within the body is lost in expiration.

For the results of Barral's experiments upon the process of respiration, see page 360.

Respecting F. Leblanc's(3) investigations upon the volume of air which, in barracks, should be secured to every individual, we must refer to the original treatise; likewise with regard to some experiments by Gorup-Besanez(4) upon the respiration in diseases.

Hervier and Saint-Sager(5) have published the following results of their experiments (not given in detail) upon the quantity of the expired carbonic acid. The amount of carbonic acid expired varies during the day, and possesses two minima and two maxima in twenty-four hours, corresponding to the regular variations of the barometer; alterations of temperature affect the expired carbonic acid in a contrary manner to that in which it is influenced by changes of pressure. The quantity of the expired carbonic acid is said to be greater under an exclusively farinaceous diet; it is also increased by rapid motion, by the inhalation of chloroform or ether, and by the use of alcoholic liquors. It is greater likewise during the waking hours: the quantity of carbonic acid is said to be less when an animal diet is employed; it diminishes also during digestion and during sleep. The air expired by children contains more carbonic acid than that expired by adults. In all

(1) J. Pr. Chem. XLVIII, 435.

(2) Berzelius' Jahresber. XXIII, 602; XXVI, 829.

(3) Ann. Ch. Phys. [3] XXVII, 373.

(4) Griesinger's Archiv. f. Physiol. Heilk. VIII. Jahrg., 719.

(5) Compt. Rend. XXVIII, 260; J. Pr. Chem. XLVII, 138.

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inflammatory diseases, except when they implicate the respiration and circulation, more carbonic acid is expired; its amount is diminished, on the contrary, in small-pox, measles, scarlatina, erysipelas, scrofula, purpura, anæmia, typhus, dysentery and phthisis; in chronic diseases, unaccompanied by fever or marasmus, no change in the quantity of expired carbonic acid takes place.

Doyère(1) has brought forward some observations upon the composition of the air expired by cholera-patients, for which we must refer the reader to the original treatise. More recently(2) it has been stated by this chemist that in the first stage of cholera the expiration of carbonic acid is diminished, and the temperature of the body sinks; shortly before death, however, an elevation of temperature takes place, whilst the quantity of expired carbonic acid is continually diminishing.

Lassaigne(3), by analysing the air of stables or kennels, has endeavoured to ascertain how much carbonic acid is expired by different animals during one hour; he found 536·8 grms. for a bull, 109·4 for a ram of eight months, 42·5 for a goat of 8 years, 23·0 for a kid of 5 months, 36·3 for a hound. Lassaigne has omitted to give the weight of the animal in each case.—By the same uncertain method of experimenting(4) he believes to prove that horses generally exhale more carbonic acid after work than before, except the Arabian horses, in which this increase is not observed; Lassaigne states that horses suffering from hydrothorax evolve less, and from inflammatory diseases, more carbonic acid than the healthy animals. According to his experiments the weight of the carbonic acid expired in one hour by sound horses, before working, was in one case 442, in another 685 grms., and after working, in one case 745, in another 755 grms.

**Statics of the Human Body.**—Barral(5) has made numerous experiments upon different individuals, determining the composition of the food and of the evacuations, in order to arrive at some more accurate data for ascertaining the proportion which exists between the constituents of the food, and of the different excretions and secretions. Of this extended investigation we can only give the most important numerical results, with the general conclusions at which Barral has arrived. Each series of experiments extended over five days; in the first and second series, the experiments were tried in winter and summer upon Barral himself (29 years of age, weighing 47·5 kilogrms.); in the third, the subject of the experiment was a boy (6 years 6 weeks old, weighing 15 kilogrms.); in the

(1) *Compt. Rend.* XXVIII, 636; *Instit.* 1849, 179; *J. Pr. Chem.* XLVII, 458.

(2) *Compt. Rend.* XXIX, 454; *J. Pr. Chem.* L, 35.

(3) *J. Chim. Méd.* [3] V, 13.

(4) *J. Chim. Méd.* [3] V, 253; *J. Pr. Chem.* XLVII, 136.

(5) *Ann. Ch. Phys.* [3] XXV, 129; *J. Pr. Chem.* XLVIII, 257. The conclusions *Compt. Rend.* XXVII, 361.

fourth, a man (age 59 years, weight 58·7 kilograms.); in the fifth, an unmarried woman (32 years of age, weight 61·2 kilograms.).—He found the mean results for one day to be those given in the table (all the weights are expressed in grammes), where A represents the amount of carbon, nitrogen, hydrogen or oxygen in the diet employed, B that excreted in the urine, C that in the fæces, and D that in the perspiration.

Statics of  
the human  
body.

	Carbon.				Nitrogen.				Hydrogen.				Oxygen.			
	A.	B.	C.	D.	A.	B.	C.	D.	A.	B.	C.	D.	A.	B.	C.	D.
1.	366·2	15·2	15·3	335·7	28·0	10·9	2·8	14·3	57·3	3·0	2·4	51·9	205·7	8·0	8·9	248·8
2.	264·9	13·7	8·9	242·3	21·2	9·8	1·3	10·1	42·8	2·8	1·3	38·7	191·4	7·2	5·6	178·6
3.	154·3	4·4	9·7	140·2	7·9	3·1	1·8	3·0	23·8	0·9	1·5	21·4	129·8	2·3	5·7	121·8
4.	331·8	21·2	13·6	296·8	27·3	15·2	2·5	9·6	49·3	4·3	2·1	42·9	265·1	11·2	8·1	245·8
5.	292·8	14·0	4·2	274·6	22·4	10·0	0·8	11·6	45·1	2·8	0·6	41·7	213·2	7·8	2·0	203·4

Barral found the relative weights of the matters assimilated and excreted, as stated in the following tables:

	ASSIMILATED.		EXCRETED.			
	Food.	Oxygen.	As water, by exhalation.	As carbonic acid.	In the evacuations.	In other ways.
1.	2755·0 (1998·6)	1061·5	1287·8	1230·9	1265·0 (1177·8)	32·8
2.	2386·0 (1842·4)	777·3	1141·6	888·4	1099·4 (1032·9)	33·9
3.	1396·2 (1069·1)	423·4	694·7	514·0	604·6 ( 567·2)	6·3
4.	2710·7 (2002·0)	889·1	522·6	1088·3	1962·8 (1865·7)	26·1
5.	2339·6 (1737·4)	886·7	998·7	1006·9	1191·6 (1138·2)	29·1

The numbers placed in parentheses denote the amount of water in the food and in the evacuations; the water in the food amounts, on an average, to about  $\frac{3}{4}$ ths.—When the results given above are calculated so that the sum of the matter assimilated and of that excreted amounts to 100, they stand as follow:

	ASSIMILATED.		EXCRETED.			
	Food.	Oxygen.	As water, by exhalation.	As carbonic acid.	In the evacuations.	In other ways.
1.	72·2	27·8	33·8	32·3	33·2	0·7
2.	75·4	24·6	36·1	28·8	34·7	0·4
3.	76·7	23·3	38·2	28·3	33·2	0·3
4.	75·3	24·7	14·5	30·2	54·6	0·7
5.	72·5	27·5	31·0	31·3	36·9	0·8

Barral determined (by indirect experiment) that the amount of carbon daily consumed in the process of respiration was as large as Andral and Gavarret had stated(1); another cause of variation in

States of  
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the amount of carbon consumed must be added to those which the last-named observers have pointed out, since it is found that about  $\frac{1}{5}$ th more carbon is consumed in winter than in summer. The amount of nitrogen contained in the food is greater than that in the evacuations, so that part of the nitrogen must be separated in the process of respiration; this part amounts to  $\frac{1}{3}$ rd or  $\frac{1}{4}$ th of the nitrogen contained in the food, but only to  $\frac{1}{100}$ th of the carbonic acid formed in respiration; the ratio of the carbon to the nitrogen is about that of 100 to 8. The oxygen and hydrogen in the food are not exactly in the proportions to form water, but there is always some excess of hydrogen, part of which is converted into water in the process of respiration (the hydrogen thus oxidised being on an average equivalent to  $\frac{1}{3}$ rd of the carbon converted by respiration into carbonic acid); the other portion of the excess of hydrogen passes off in the evacuations, the hydrogen in which exceeds that in the food, in the ratio of about 8 to 5. The amount of oxygen which is necessary to convert the carbon and hydrogen of the food consumed in respiration into carbonic acid and water, stands to the food thus consumed in the ratio of 1 to 3. The water (both that which was already present and that formed in digestion) amounts on an average to 75 per cent of the weight of the food, and 67 per cent of the sum of the weights of the food and of the oxygen which combines with it. In general, more water passed off by exhalation than in the evacuations. In three series of experiments more chlorine was found in the food, and in two others a little less, than in the evacuations. The heat generated in the body being represented by 100, it is carried off in the following proportions: by the perspired water 24.1; by the air in respiration 7.3; by the food 2.2; by the evacuations 1.8; by radiation and conduction 64.6.

**States of Animal Bodies.**—Jörgensen(1) has determined, by observations on a wether, extending over about four weeks, the proportion which exists between the constituents of the food consumed and those of the excrements (including the urine). A represents the quantity of each constituent consumed by the animal, and B that obtained in the excrements.

	Nitrogen.	Carbon.	Hydrogen.	Oxygen.	Water.	Inorganic matter.
A.	14.31	355.12	39.34	293.67	1394.67	66.50
B.	13.27	201.40	37.76	247.26	972.22	76.34

To account for the circumstance that a larger amount of inorganic matter was found in the evacuations than in the food, Jörgensen states that the specimen of the food selected for examination, was more carefully cleansed from dust than that consumed by the animal.

(1) From the Arch. for Pharm. og Technisk Chem. I, 354 in Jahrb. Pr. Pharm. XVIII, 264.

The chlorides contained in the food were found almost entirely in the urine; the high specific gravity of the urine, he says, indicated the presence of a large amount of hippuric acid.

Statics of  
animal  
bodies.

Lassaigue(1) found the amount of nitrogen contained in the millet (23.5 grms.) which was consumed by a greenfinch in 4 days, to be 0.164 grm., the nitrogen in the excrements (weighing, when dried, 7.5 grms.) during the same period, amounting to 0.072 grm.

**Digestion.**—Lehmann(2) has published numerous experiments, as contributions towards the solution of the question concerning the proportion which should exist between the digestive ferment, the free acid, and the water, in order to convert into its corresponding peptone, the greatest possible quantity of any nitrogenised aliment (albumin, gelatin, &c.); his investigations also relate to the inquiry whether the various organic or inorganic acids, which may be substituted for the acids of the stomach, act according to their chemical equivalents, or whether their operation is modified by other circumstances; he has finally endeavoured to determine what numerical ratio exists between the various albuminous, or gelatinous substances, with regard to their solubility in the gastric juice. We cannot attempt to give in the form of an abstract the extensive series of experiments, conducted by Lehmann, with artificial digestive mixtures of different composition, but must refer the reader to the original paper: we can here only bring forward the general conclusions which Lehmann has pointed out.—If the amount of water in a mixture of pepsin and dilute hydrochloric acid be increased, the mixture will be capable of converting a larger quantity of aliment into peptone; the quantity of pepsin remaining the same, the solvent power of any digestive mixture may be considerably augmented, by increasing the quantity of water or of hydrochloric acid. When alkaline salts are added in any quantity to the gastric juice, and are not, as in the natural process of digestion, quickly removed again, the solvent power of the gastric juice is considerably diminished, if not annihilated. It is probable that in the process of digestion equivalent quantities of hydrochloric and lactic acids can replace each other; the digestive power of acetic and phosphoric acids is far inferior to that of hydrochloric and lactic acids.

**Lactic Acid in the Liquid from the Stomach.**—Heintz(3) found that the acid liquid from the stomach, vomited by a woman suffering from dyspepsia, contained lactic acid(4) of the ordinary modification (as it is formed from sugar), and not that which is furnished by

(1) J. Chim. Méd. [3] V, 620.

(2) Berichte der Gesellschaft der Wissensch. zu Leipzig, 1849, Nr. 1; J. Pr. Chem. XLVIII, 110.

(3) Jenaische Ann. f. Physiol. und Med. I, 222; Chem. Gaz. 1849, 426.

(4) With regard to these different modifications of lactic acid, compare the Annual Report for 1847 and 1848, I, 397, *et seq.*



Pancreatic  
juice.

muscular flesh (paralactic acid). The lactate of oxide of zinc prepared from this acid (the nature of which was carefully ascertained by analysis), contained 3 equivs. of water of crystallisation.

**Pancreatic Juice.**—From an examination of the pancreatic juice, Bernard(1) has arrived at the conclusion that it is destined, independently of the other liquids of the intestines, to modify or digest, in a peculiar manner, the neutral fats contained in the food, and to render them capable of being absorbed into the capillaries; the pancreatic juice, even out of the body, possesses the property of immediately emulsifying the neutral fats, and of decomposing them into fatty acids and glycerin. Bernard's results have been confirmed by Magendie, Milne-Edwards and Dumas(2).—Frerichs(3) disputes this view of the operation of the pancreatic juice. He found the pancreatic juice of the ass clear and colourless, of sp. gr. 1·0082, becoming hardly perceptibly turbid on boiling (according to Bernard, this property is possessed only by the abnormal, morbid secretion); he believes that the secretion examined by him was healthy; it contained in 1000 parts, 986·4 of water and 13·6 of solid matter, consisting of 0·26 fat, 0·15 alcohol-extractive, 3·09 water-extractive and caseous matter, 8·9 chloride of sodium, tribasic phosphate of soda and alkaline sulphate, 1·20 of carbonate and phosphate of lime and magnesia. The deportment of the pancreatic juice of the dog was essentially the same; it contained in 1000 parts 16·2 of fatty matter, and when heated to boiling, deposited some albumin (it contained, however, traces of blood). Frerichs believes the functions of the pancreatic juice to be, to convert the farinaceous nutriment into sugar in the intestinal canal, to accelerate the decomposition of the bile into insoluble products, and, in conjunction with the bile and the intestinal fluid, to effect the minute division of the neutral fats. The pancreatic juice soon emulsifies olive-oil, but the serum of blood, the bile and saliva, possess this property almost in the same degree.

**Liquid of the Intestines.**—Frerichs has likewise examined the intestinal secretion. He found it of a vitreous transparency, colourless, viscid, not easily miscible with water, and only very slightly soluble therein; the filtrate scarcely became opalescent when heated. In 1000 parts of the intestinal secretion from the colon of cats and dogs he found 950·55 water and 24·45 solid matter consisting of 8·70 insoluble mucus with cells and their nuclei, 5·40 soluble mucus and extractive matter, 1·95 fat, 8·40 chloride of sodium, alkaline

(1) Ann. Ch. Phys. [3] XXV, 474; J. Pharm. [3] XV, 336; J. Pr. Chem. XLVIII, 102; Compt. Rend. XXVIII, 249 (in abstr.); Ann. Ch. Pharm. LXXII, 322.

(2) Compt. Rend. XXVIII, 283; Instit. 1849, 65.

(3) Nachr. der Gesellsch. d. Wissensch. zu Göttingen, Juli, 1849; R. Wagner's Handwörterbuch d. Physiol. III, Abth. 1, 842 ff.; Instit. 1849, 309.

phosphates and sulphates, and earthy phosphates. In the small intestine, the solid portion of the *sécrétion* had a composition similar to the above, but amounted to 26.5 parts in 1000.

Nutrition.

**Nutrition.**—Henneberg(1) has brought forward some observations made upon sheep with a view to determine the relation existing between the nitrogen contained in different kinds of food and their nutritive power (compare *Agricultural Chemistry*). He has arrived at the conclusion that in those kinds of food which belong, in respect of their chemical composition, to the same group, the nutritive power is proportionate to the amount of nitrogen (he considers the hay of grass, the hay and straw of the *leguminosæ*, the straw of the *cerealia*, roots, and lastly grains, as members of such groups); this proportionality, however, is no longer observed between those kinds of food which belong to different groups. Upon this subject it has been remarked by Lassaigue(2), that in replacing one species of food by another, more regard should be had to the results of the chemical analysis, in order that a quantity of the new description of food may be employed, which contains as much nitrogen as that for which it is to be substituted.

**Chyle. Blood.**—In the arterial blood of a dog fed upon milk, Millon(3) found carbon and nitrogen in the same proportions as in albumin, but much more oxygen; the organic matter contained in the chyle possessed exactly the same composition, but its quantity was only  $\frac{1}{3}$ rd of that in arterial blood. The same similarity in composition was also exhibited by the organic portions of the arterial blood and the chyle of a dog maintained upon a very fat diet; in this case also carbon and nitrogen were found in the same proportions as in albumin, but with an excess of hydrogen. No increase was observed in the amount of fat contained in the chyle.

In order to determine the quantity of blood in the body of any animal, Weiss(4) estimates the iron in a known weight, then incinerates the whole animal, and deduces the amount of the blood from that of the iron contained in the ash.—Vanner(5) concludes from observations made upon horned cattle in the slaughterhouses of Paris, that the quantity of blood is pretty constant at 5 per cent of the weight of the living animal; he farther states, that in cholera, a considerable quantity of the serum passes into the evacuations, and hence the blood remaining behind is much less free to circulate.

(1) *Ann. Ch. Pharm.* LXIX, 336.

(2) *J. Chim. Méd.* [3] V, 424.

(3) *Compt. Rend.* XXIX, 817; *J. Pr. Chem.* L, 30.

(4) From the *Mittheil. von Freunden der Naturwissensch. zu Wien*, III, in *J. Pr. Chem.* XLVI, 507.

(5) *Compt. Rend.* XXVIII, 649.

Chyle.  
Blood.

G. Reich(1) states that, according to his experiments, venous blood contains phosphorus (dissolved in the fat of the blood-globules), but no phosphates, and that arterial-blood, on the contrary, contains phosphates (compare the view of Owen Rees, Annual Report for 1847 and 1848, II, 153).—Marchal(2) found that blood coagulated between 55° and 60° contained more fibrin than that coagulated in the cold; if coagulated at above 70°, the amount of fibrin was less.

A specimen of white blood has been examined by Chatin and Sandras(3); it furnished 200 grms. of serum, and 60 grms. of clot; in the former there were suspended 6 per cent of a fatty substance, in which they found 0·07 per cent of the substance described by F. Boudet(4) as *serolin*, 1·23 cholesterin, 66·5 olein, and 32·20 margarin.

**Blood.**—Garrod(5) has communicated the following results with regard to the alteration of the blood in disease. In gout, the blood contained uric acid in the form of urate of soda, which may be obtained from it in crystals (1000 of serum are stated to have yielded, in different cases, from 0·025 to 0·175 of uric acid); immediately before the attack of gout the uric acid in the urine suffers a diminution; in chronic gout, with depositions in the joints, a certain amount of uric acid is always present in the blood, whilst in the urine it is small, whether viewed alone, or in relation to the other organic constituents. In gout the blood sometimes contains urea, whilst no albumin can be found in the urine.—In rheumatism the blood contains no more uric acid than might be accounted for by the normal variations, and in 1000 grms. of serum no urea could be detected. Respecting the blood in Bright's disease, and in albuminuria after scarlatina, Garrod states that in albuminuria uric acid is always present in the blood, although in very variable proportion; in serious affections of the kidneys its quantity may be as great as in gout, but in any case exceeds that in normal blood; urea is present in the blood in these diseases, but its quantity bears no estimable proportion to that of uric acid.

Gorup-Besanez(6) has published some experiments upon the composition of the blood before and after the inhalation of ether (the general result observed being an increase of water and diminution of blood corpuscles); he has also studied the blood in different diseases.

(1) Arch. Pharm. [2] LVII, 12.

(2) Compt. Rend. XXIX, 212; J. Pharm. [3] XVI, 221 (in the latter, Bernard's critical remarks are given).

(3) J. Chim. Méd. [3] V, 305; J. Pr. Chem. XLVII, 427.

(4) Ann. Ch. Phys. [2] LII, 337; Berzelius' Jahresber. XIV, 372.

(5) Med. Chir. Transactions, XXXI, 83; Schmidt's Jahrb. d. Ges. Med. LXII, 4.

(6) Griesinger's Archiv f. Physiol. Heilk. VIII. Jahrg., 514.

Verdeil and Dollfus(1) have detected hippuric acid in the blood of oxen.

With regard to Guérin-Ménéville's(2) observations upon the composition of the blood of silk-worms, in health and disease, we must refer to the original treatise.

**Inorganic Constituents of Blood.**—Cottureau(3) found in 450 grms. of human blood 0.315 milligram. of iron, together with traces of manganese and very slight traces of copper, but no lead.—According to Malaguti, Durocher and Sarzeaud, the blood of oxen contains some silver (compare the article "Sea-water").

Verdeil(4) has examined the ashes of the blood of man and other animals (with regard to the method, compare the report upon Analytical Chemistry). We subjoin the percentage-composition, after deducting the carbon still contained in the ash.

	Dog.		Ox.		Sheep.		Pig.		Calf.		Man.	
	A.*	B.**	A.	B.	A.	B.	A.	B.	A.	B.	A.†	B.††
Chlorine . . .	30.25	30.94	35.88	32.60	34.66	30.72	25.07	30.05	30.43	36.13	37.50	33.76
Sodium . . .	19.60	20.04	23.24	21.11	22.45	19.90	16.24	19.46	19.73	23.40	24.49	21.87
Soda . . .	5.78	2.02	13.00	14.40	13.33	13.40	7.62	5.33	10.39	10.41	2.03	6.27
Potassa . . .	15.16	19.16	5.60	8.76	5.29	7.93	22.21	18.54	11.74	9.81	12.70	11.24
Magnesia . . .	0.67	4.38	0.47	0.59	0.30	0.82	1.21	0.97	1.15	1.19	0.99	1.26
Sulphuric acid . . .	1.71	1.08	1.25	1.16	1.65	1.91	1.74	1.34	1.34	1.21	1.70	1.64
Phosphoric acid . . .	12.74	9.34	3.40	3.02	3.83	3.41	10.61	11.48	4.91	3.76	7.48	9.74
Phosphoric acid . . .	1.22	2.35	1.66	1.62	1.38	1.58	1.68	1.27	3.45	2.97	1.87	1.36
Lime . . .	0.10	0.70	0.85	0.70	1.00	1.10	1.20	1.90	1.85	1.60	1.68	1.85
Sesquioxide of iron . . .	12.75	8.65	9.00	8.80	8.70	9.17	9.10	9.52	8.11	7.80	8.06	8.68
Carbonic acid . . .	0.53	0.37	6.57	6.49	7.09	6.35	0.69	0.36	3.77	3.57	1.43	0.95

\* After a flesh diet of 18 days.

\*\* After feeding for 20 days upon bread and potatoes.

† Man of 45 years of age, suffering from weak digestion.

†† Single woman of 22 years of age, sanguineous temperament, well nourished.

H. Rose(5) has communicated an analysis, made by R. Weber, according to his method(6), of the ash of ox-blood. The aqueous solution of the carbonised blood left 3.92 grms. of residue of the percentage-composition A; the hydrochloric solution left 0.533 gm. (only 0.389 gm. was accounted for in the analysis) of the composition B; the ash of the charcoal after exhaustion with water and hydro-

(1) Compt. Rend. XXIX, 789; Instit. 1849, 410; Arch. Ph. Nat. XIII, 60. The analyses more recently brought forward by Verdeil and Dollfus as evidence of the truth of this statement (1850; Compt. Rend. XXX, 657; Ann. Ch. Pharm. LXXIV, 214) must relate to hippurate of lime, and not (as might be supposed from the paper) to crystallised hippuric acid (found 54.7 per cent carbon and 4.3 hydrogen).

(2) Compt. Rend. XXIX, 499.

(3) J. Chim. Méd. [3] V, 179.

(4) Ann. Ch. Pharm. LXIX, 89.

(5) Pogg. Ann. LXXVI, 367; J. Pr. Chem. XLVIII, 50; Phil. Mag. [3] XXXV, 185.

(6) Annual Report for 1847 and 1848, II, 237; compare Analytical Chemistry in the present Report.

Inorganic  
constituents  
of blood.

chloric acid, weighed 2.128 grms., and had the composition C; the composition of the entire ash, calculated from these results, is given at D.

	A.	B.	C.	D.
Chloride of sodium . . . . .	59.31	—	—	36.16
Soda . . . . .	14.67	41.39	47.22	27.08
Potassa . . . . .	11.91	12.60	7.94	10.66
Lime . . . . .	—	6.95	4.09	1.77
Magnesia . . . . .	—	4.10	1.46	0.73
Sesquioxide of iron . . . . .	—	21.60	16.69	6.84
Phosphoric acid . . . . .	0.53	13.36	18.37	7.21
Sulphuric acid . . . . .	0.36	—	0.61	0.42
Carbonic acid . . . . .	13.01	—	—	7.91
Silica . . . . .	—	—	3.62	1.19

**Flesh.**—G. Liebig(1) found 49 per cent of fat in a muscle from the upper part of the thigh of a dead body, in which all the muscles (except those of the digestive organs) appeared to have been converted into fat.

In the flesh of an alligator, the carcase of which was sent to Giessen, there were found a great number of small needles, which appeared under the microscope to be crystals of uric acid, a result which was confirmed by the more accurate chemical examination.

**Juice of Flesh.**—In the preparation of the constituents of the juice of flesh, according to the method described by Liebig(2), Scherer(3) found, that if the residue obtained by evaporating, together with baryta-water, the mother-liquid from which the creatin has been crystallised, be distilled with sulphuric acid, volatile fatty acids may be obtained, together with lactic acid; he also obtained a distillate containing volatile acids from a mixture of the juice of flesh, the albumin of which had been coagulated by heat, with sulphuric acid. The want of material prevented his obtaining pure products, but he considered that his experiments proved that the juice of human flesh, as well as that of the mammalia, contains volatile acids, consisting partly of volatile fatty acids (such as butyric acid), partly of acetic, and probably also formic acid.

**Ashes of Flesh.**—F. Keller(4) has examined the ash of the aqueous extract of flesh (broth), and of the flesh which has been boiled out with water (with regard to the method employed, compare the Report upon Analytical Chemistry). 10 lbs. of flesh yielded an extract which left 35.28 grms. of ash, and a residue containing

(1) Ann. Ch. Pharm. LXX, 343.

(2) Annual Report for 1847 and 1848, II, 161.

(3) Ann. Ch. Pharm. LXIX, 196.

(4) Ann. Ch. Pharm. LXX, 91.

7.64 grms. of ash, so that of the total ash (42.92 grms.) 82.2 per cent were obtained from the broth, and 17.8 per cent from the residue.

Ashes of  
flesh.

	Ash of the broth from flesh		Ash of the residue		Ash of the flesh	
	soluble in water.	insoluble in water.	soluble in water.	insoluble in water.	in the broth.	in the residue.
PO <sub>5</sub>	23.55	2.72	5.92	32.48	21.59	6.83
{ Cl	8.25	0.38	—	—	7.09	—
{ K	8.98	0.42	—	—	7.72	—
{ SO <sub>3</sub>	3.21	0.38	—	—	2.95	—
{ KO	3.78	0.45	—	—	3.17	—
KO	34.18	4.69	6.76	20.13	31.95	4.78
PO <sub>5</sub> { 2 CaO	—	3.06	0.29	9.05	2.51	1.66
{ 2 MgO	—	5.76	0.57	16.26	4.73	2.99
{ 2 Fe <sub>2</sub> O <sub>3</sub>	—	0.57	0.05	7.97	0.46	1.42
Total . . .	81.95	18.43	13.59	85.89	82.47	17.68
	100.38		99.48		100.15	

From these analyses Keller deduces the following conclusions. Nearly 3/4ths of the saline matters contained in the flesh may be extracted by boiling with water. Part of the earthy phosphates, and even of phosphate of sesquioxide of iron, contained in the ash, pass into the broth by the intervention of the alkaline phosphates. Even flesh which has been thoroughly boiled out with water, is still always rich in alkaline phosphates, although the phosphates of the earths predominate. The phosphates of the flesh contain invariably but 2 equivs. of fixed base for 1 equiv. of phosphoric acid; the ashes of the broth, it is true, gave a certain quantity of tribasic salts, but the residue left by water gave, on incineration, a corresponding quantity of alkaline metaphosphate, so that, by incinerating the original flesh, pyrophosphates only are obtained. Keller is of opinion that the excess of potassa in the ash of the broth was originally present in the form of carbonate, and that the excess of phosphoric acid in the ash of the residual flesh was formed during incineration from the phosphorus of the tissues.

H. Rose(1) has communicated an analysis, made according to his method(2), by R. Weber, of the ashes of horse-flesh. He employed the muscles of the fore-arm of a lean horse, which had been freed from blood by injection. The aqueous solution of the carbonised flesh left 3.09 grms. of residue of the percentage-composi-

(1) Pogg. Ann. LXXVI, 372; J. Pr. Chem. XLVIII, 51; Phil. Mag. [3] XXXV, 271.

(2) Annual Report for 1847 and 1848, II, 237; see Analytical Chemistry in the present Report

Ashes of  
flesh.

tion A; the hydrochloric solution left 1.262 grm. of the composition B; the charcoal, after exhaustion with water and hydrochloric acid, gave 2.866 grms. of ash of the composition C; the composition of the entire ash calculated from these results is given at D.

	A.	B.	C.	D.
Chloride of sodium . . .	3.43	—	—	1.47
Potassa . . . . .	48.19	26.47	36.64	39.95
Soda . . . . .	5.18	4.36	4.71	4.86
Lime . . . . .	—	6.02	1.88	1.80
Magnesia . . . . .	—	12.20	4.36	3.88
Sesquioxide of iron . . .	—	3.96	0.76	1.00
Phosphoric acid . . . .	41.68	46.99	51.65	46.74
Sulphuric acid . . . . .	0.71	—	—	0.30

**Arterial Coats.**—M. S. Schultze(1) has examined the coats of the arteries of oxen. He found in 100 parts of the fresh circular fibres :

	Carotid.			Thoracic aorta.	
Water . . . . .	69.3	71.4	72.9	67.8	73.3
Solid matter . . . . .	30.7	28.6	27.1	32.2	26.7

and in 100 parts of the solid matter :

Constituents of the fibres insoluble in water	60.7	60.5	63.2	76.9	82.6
Salts insoluble in water	1.1				
Casein	21.0	39.5	36.8	23.1	10.2
Albumin	7.4				
Extractive matters	7.4				
Salts soluble in water	2.4				

In that portion of the contracted arterial fibres which was insoluble in water, Schultze found one of the so-called protein-substances; he supposes that the gelatinous matter of the elastic tissue is similar to gluten, and perhaps completely identical with it.

**Bones.**—Heintz(2) has again determined the composition of bones. His experiments confirm the statement that the bones of vertebrate animals contain a small amount of fluoride of calcium; they show that the mass of the true bony structure which gives firmness to the bones by reason of its insolubility, is perfectly free from chlorides, from sulphates, and from iron, and that when these last were found in the bones, the liquid pervading them had not been entirely removed. Heintz found that the fixed bases in the bones were sufficient to saturate completely the acids contained in them, so that the phosphate of lime, as well as the phosphate of magnesia

(1) Ann. Ch. Pharm. LXXI, 277.

(2) Pogg. Ann. LXXVII, 267; Berl. Acad. Ber. 1849, 50; Ann. Ch. Pharm. LXXII, 264; J. Pr. Chem. XLVIII, 24; Instit. 1849, 244; J. Pharm. [3] XVI, 226.

which the bones contain, are composed according to the formula  $3 \text{ CaO}, \text{PO}_5$  (Berzelius had considered the lime-salt in question to  $8 \text{ CaO}, 3 \text{ PO}_5$ ; however, many other chemists had already opposed this view.) The experiments of Heintz relate, I to the composition of the most compact portion of the *femur* of an ox, II to the strongest part of the *femur* of a sheep; III and IV to portions of average strength from the upper part of the *femur* of a woman who died of *typhus abdominalis*; (the bone was dried at  $150^\circ$ ; the three first analyses were made with carbonised, the last with uncarbonised bone.

	I.	II.	III.	IV.
Lime . . . . .	37.46	40.00	37.89	37.51
Magnesia . . . . .	0.97	0.74	0.57	0.56
Phosphoric acid . . . . .	27.89	29.64	28.27	28.00
Carbonic acid . . . . .	3.10	3.08	2.80	2.81
Loss (organic matter, fluorine, water)	30.58	26.54	30.47	31.12

If the carbonic acid be considered as in combination with lime, the magnesia as  $3 \text{ MgO}, \text{PO}_5$ , and the phosphate of lime as  $3 \text{ CaO}, \text{PO}_5$ , the composition of the bones becomes:

	I.	II.	III.	IV.
Carbonate of lime . . . . .	7.07	7.00	6.36	6.39
Phosphate of magnesia ( $3 \text{ MgO}, \text{PO}_5$ ) . . . . .	2.09	1.59	1.23	1.21
Phosphate of lime ( $3 \text{ CaO}, \text{PO}_5$ ) . . . . .	58.30	62.70	60.13	59.67
Lime . . . . .	1.96	2.17	1.81	1.62
Organic matter, &c. . . . .	30.58	26.54	30.47	31.11

If the excess of lime be taken into calculation as fluoride of calcium, the percentage-composition of the inorganic portion of the bones will be represented as follows:

	I.	II.	III.	IV.
Carbonate of lime . . . . .	10.07	9.42	9.06	9.19
Phosphate of magnesia ( $3 \text{ MgO}, \text{PO}_5$ ) . . . . .	2.98	2.15	1.75	1.74
Phosphate of lime ( $3 \text{ CaO}, \text{PO}_5$ ) . . . . .	83.07	84.39	85.62	85.83
Fluoride of calcium . . . . .	3.88	4.05	3.57	3.24

By direct estimation of the fluorine in the above-mentioned human bones (dried at  $150^\circ$ ), Heintz found 2.05, or in the inorganic portion, 2.97 per cent of fluoride of calcium.

**Softened skulls of Children.**—Schlossberger(1) has published some experiments upon the softened bones of the skull in children. In different cases (designated by different letters) he obtained the subjoined results. ( $A_1$  an abnormally thin portion of the parietal bone,  $A_2$  spongy portion of the frontal bone; B occipital bone; C frontal and occipital bones; D frontal bone of a child which had been cured of softening of the bones of the skull; E frontal bone: the bones were macerated for a moderate period). In the normal sound bones of the skull of children from 1 to 38 days old, Schlossberger found 61

(1) Ann. Ch. Pharm. LXX, 14.



Softened  
skulls of  
children.

to 66 of inorganic matter, and 39 to 34 of organic matter (in one case, where the bone had not been macerated, and was saturated with blood, 55 to 60 of inorganic matter, and 45 to 40 of organic matter were obtained); in a complete analysis of the occipital bone, he obtained the results given at F. Schlossberger communicates, in addition to these, an analysis of the occipital bone of the compressible skull of a child of 14 days (G).

	A <sub>1</sub> .	A <sub>2</sub> .	B.	C.	D.	E.	F.	G.
Organic matter . . . .	48.5	71.8	47.7	48.1	41.2	59.6	61.2	44.8
Inorganic matter . . . .	51.5	28.2	52.3	51.9	58.8	40.4	38.8	55.2
Composition of the substance:								
Cartilage and vessels . . . .	47.6	71.8	47.7	46.6	40.2	57.6	36.9	44.7
Fat . . . . .	0.9							
Phosphate of lime . . . .	45.5	22.9	43.0	46.2	54.2	35.6	55.9	49.1
Phosphate of magnesia . . . .								
Carbonate of lime . . . .	4.3	1.8	6.4	5.7	4.6	3.1	5.5	6.9
Soluble salts . . . . .	—	1.0	2.9	—	—	—	trace	—
Loss . . . . .	1.7	2.4						

With regard to Schlossberger's comparisons and conclusions, we must refer to the original treatise.

**Ox-Bile.**—Strecker(1) has published a comparison of his own views and results with those of Mulder respecting the constituents of ox-bile, and the substances obtained from it, and has pointed out, in a critique upon the statements of the latter chemist, supported by several original experiments, that the formulæ assigned by himself are to be preferred, and that those of Mulder are inadmissible. A comparison of the results and opinions of both chemists has been given in the preceding Annual Report(2), we shall, therefore, now consider only the results of Strecker's later experiments.

Strecker(3) has again endeavoured to obtain *dialysin* in a state of purity by repeated solution in ether and reprecipitation by absolute alcohol; it became lighter, but was still of a sooty-grey colour. When dried at 120° it gave on analysis:

	Carbon.	Hydrogen.	Oxygen.
Found (Strecker) . . . .	77.3	9.7	—
C <sub>48</sub> H <sub>36</sub> O <sub>6</sub> (Strecker) . . . .	77.4	9.7	12.9
C <sub>100</sub> H <sub>73</sub> O <sub>13</sub> (Mulder) . . . .	77.1	9.4	13.5

For *cholalic acid*(4), Mulder had proposed the formula C<sub>100</sub>H<sub>81</sub>O<sub>21</sub> without taking into consideration the composition of its salts; Strecker had assigned to it the composition C<sub>48</sub>H<sub>40</sub>O<sub>10</sub>. The latter

(1) Ann. Ch. Pharm. LXX, 149; Chem. Gaz. 1849, 427; J. Pharm. [3] XVI, 450.

(2) Annual Report for 1847 and 1848, II, 175, *et seq.*

(3) Annual Report for 1847 and 1848, II, 185.

(4) Annual Report for 1847 and 1848, II, 180.

has prepared cholalate of potassa under such conditions that it could not contain an excess of base; he dissolved crystallised cholalate of potassa (which had a feebly alkaline reaction) in absolute alcohol, added cholalic acid till the reaction became distinctly acid, precipitated the salt by ether, and washed with a mixture of alcohol and ether. The salt dried at  $100^{\circ}$  did not decrease in weight at  $140^{\circ}$ ; its composition was the same as Strecker found at an earlier period:

Ox-bile.

	Carbon.	Hydrogen.	Oxygen.	Potassa.
Found (Strecker)	64.7 and 64.6	8.7 and 8.8		10.4
$C_{48}H_{39}O_9$ , KO (Strecker)	64.6	8.7	16.1	10.6
$C_{100}H_{79}O_{19}$ , 2 KO (Mulder)	64.9	8.5	16.4	10.2

Cholalic acid contains, therefore, 48 equivs. of carbon, and thus confirms moreover the formulæ of chololoidic acid, dyslysin, cholic and choleic acids.

Buchner, Junr.(1) has brought forward some observations upon the spontaneous decomposition of ox-bile; he finds that in the first stage of the putrefaction (induced by the decomposition of the mucus of the gall-bladder, and completed in from 4 to 6 weeks), ammonia and taurin are formed (which contain the whole of the nitrogen and sulphur of the bile), together with a resinous acid free from nitrogen and sulphur (choloidic or cholalic acid), as the chief products. He recommends this process for the preparation of taurin. —At a later stage of the process the taurin disappears, and there are formed, first a lower oxide of sulphur, and afterwards sulphuric acid. When the putrefaction has been allowed to continue for six months, sulphate of soda (which was not present in the fresh bile) is found in the liquid; the mother-liquor from the crystals of this salt evolves much sulphurous acid upon addition of a stronger acid. In putrefied bile not only acetic acid is present, but also other analogous acids, especially valerianic.

Van Heijningen and Scharlée(2) have determined, in ox-bile dried at  $120^{\circ}$ , the amount of mucus (insoluble in spirit of 32 degrees), the sulphuric acid, and the total amount of sulphur (by deflagrating with caustic soda and nitrate of potassa). From different analyses they obtained the following mean percentage-results:

	Mucus.	Sulphuric acid.	Sulphur.
1.	5.62	0.32	3.37
2.	4.71	0.37	2.86

H. Rose(3) has communicated an analysis made according to his

(1) Repert. Pharm. [3] II, 289; Anzeigen d. Bair. Acad. Nr. 232; J. Pr. Chem. XLVI, 147; Chem. Gaz. 1849, 189; J. Pharm. [3] XV, 401.

(2) Loc. cit. page 375 of the present Report.

(3) Pogg. Ann. LXXVI, 386; J. Pr. Chem. XLVIII, 57; Phil. Mag. [3] XXXV, 278.

Ox-bile.

method(1) by Weidenbusch, of the ash of ox-bile. The aqueous solution of the carbonised bile left 16·018 grms. of residue of the percentage-composition A; the hydrochloric solution left 0·869 grm. of residue of the composition B; the charcoal exhausted with water and hydrochloric acid, gave 0·744 grm. of ash of the composition C. The composition of the entire ash calculated from these results is stated at D. Rose remarks, moreover, that the amount of sulphuric acid given in C and D is too small, since all the sulphur was not oxidised by the nitric acid.

	A.	B.	C.	D.
Chloride of sodium . . . . .	28·77	—	—	27·70
Potassa . . . . .	4·51	3·70'	6·71	4·80
Soda . . . . .	35·79	11·50	40·49	36·73
Lime . . . . .	—	27·00	2·45	1·13
Magnesia . . . . .	—	7·41	4·01	0·53
Sesquioxide of iron . . . . .	—	4·21	0·80	0·23
Proto-sesquioxide of manganese . . . . .	—	2·11	—	10·12
Phosphoric acid . . . . .	8·55	41·63	3·89	0·15
Sulphuric acid . . . . .	1·81	—	41·63	6·39
Carbonic acid . . . . .	11·70	—	—	11·26
Silica . . . . .	0·26	2·41	—	0·36

**Pig's Bile.**—Gundelach and Strecker(2) had discovered that the chief constituent of pig's bile is an acid free from sulphur, which they designate *hyocholic acid*; the composition assigned by them to this acid is  $C_{54}H_{43}NO_{10}$ , and to its salts  $RO, C_{54}H_{43}NO_{10}$ . For that portion of the bile which is soluble in alcohol and insoluble in ether, they had found a somewhat different composition; it contained 0·47 per cent of sulphur. Strecker had since expressed his opinion(3) that the latter might be due to the presence of a small quantity of a constituent of pig's bile which corresponds to the cholic acid of ox-bile; he had communicated some experiments(4) in which, by the decomposition of pig's bile, a substance was obtained soluble in water and containing sulphur (probably taurin). Strecker had pointed out the relation existing between hyocholic acid and one of the constituents of ox-bile, cholic acid(5), from which, by abstraction of the elements of water, a new acid, cholonic acid, is obtained, analogous to hyocholic acid, which differs from it by containing  $C_2H_2$  in addition; he(6) had found that hyocholic acid, when

(1) Annual Report for 1847 and 1848, II, 237; see Analytical Chemistry in the present Report.

(2) Annual Report for 1847 and 1848, II, 188.

(3) Ann. Ch. Pharm. LXV, 36; Annual Report for 1847 and 1848, II, 188.

(4) Liebig, Poggendorff and Wöhler's Handwörterb. d. Chemie III, 250; Annual Report for 1847 and 1848, II, 188.

(5) Ann. Ch. Pharm. LXV, 37; Annual Report for 1847 and 1848, II, 188.

(6) Liebig, Poggendorff and Wöhler's Handwörterb. d. Chemie III, 250; Annual Report for 1847 and 1848, II, 190.

boiled with acids or alkalis, split up into glycocine and a non-nitrogenised acid.—The earlier results here pointed out have given rise to various discussions supported by the communications of Van Heijningen and Scharlée, and by new experiments on the part of Strecker.

Pig's bile.

Van Heijningen and Scharlée(1) have examined the bile of pigs under Mulder's direction. In different analyses they found the following as the mean percentage-composition of the bile dried at 120°. (See. p. 373).

	1.	2.	3.	4.	5.
Mucus	2.68	1.65			
Sulphur	1.52	1.42	0.84	0.96	1.90
Ash			10.08	10.01	

but no determinable quantity of sulphuric acid. That portion of the bile which was soluble in boiling alcohol of 32 degrees, was dissolved, after evaporation of the alcohol, in warm water, and the solution precipitated with neutral acetate of lead. The liquid, after separation of the lead by sulphuretted hydrogen, left on evaporation an impure mass somewhat similar in appearance to the so-called bilin. The lead-precipitate was suspended in water, decomposed by sulphuretted hydrogen, and boiled with water; the aqueous solution did not deposit crystals of cholic acid, but on evaporation, a small quantity of a resinous substance was left of the same kind as that remaining behind with the sulphide of lead; the latter was exhausted with alcohol of 32 degrees; by slow evaporation on the water-bath, there separated from the alcoholic solution, first, a small quantity of white needles similar in appearance, and in the amount of sulphur which they contained, to taurin, and afterwards a brown resinous substance. The latter consisted of impure hyocholic acid containing sulphur, for which, disregarding the admixture of the sulphurised substance, the formula  $C_{54}H_{43}NO_{11}$  was found (both in the acid itself and in the lead-salt); this substance was named by Mulder *Fellonic acid*. By boiling this acid for several hours with strong hydrochloric acid, a solution containing glycocine was obtained, and a dark brown residue, of which the part insoluble in alcohol had the same composition as the dyslysin which separates from the alcoholic solution of ox-bile (the preparation obtained from the so-called fellonic acid, dried at 130°, contained 76.07 per cent carbon and 9.67 per cent hydrogen). Consistently with his former views, Mulder regards pig's bile as an unstable substance, and fellonic or hyocholic acid as a product of its decomposition.

In a critique upon this paper, Strecker(2) has corrected the errors and obscurities which it contains, by relating various original experi-

(1) Scheikund. Onderzoek; V, 2. Stuk, 105.

(2) Loc. cit. p. 372.

Pig's bile. ments, and has confirmed and amplified the conclusions drawn from his former investigation.. He has again analysed the pure hyocholic acid dried at  $130^{\circ}$ , and still finds a composition corresponding with the formula  $C_{54}H_{43}NO_{10}$  (found, 70.16 per cent carbon and 9.51 hydrogen). Strecker believes that the sulphurised acid found in pig's bile, hyocholic acid (which yields taurin as a product of decomposition, whilst hyocholic acid furnishes glycocine under the same circumstances), differs from hyocholic acid by containing  $H_2S_2O_2$  in addition (the difference between the formulæ of taurin and glycocine); its formula would then be  $C_{54}H_{45}NO_{12}S_2$ . This chemist has also pointed out that the composition found by Van Heijningen and Scharlée for the acid which they analysed, as well as for the lead-salt, agrees as nearly as possible with that of a mixture of hyocholic acid with a quantity of hyocholic acid, which corresponds to the amount of sulphur found in the acid and in the lead-salt.

Strecker found in pig's bile a small quantity of a remarkable substance which was obtained in the following manner. Fresh pig's bile was precipitated with dilute hydrochloric acid; the hydrochloric solution was mixed with that obtained by boiling the precipitate with hydrochloric acid, and subsequently boiling the residue with water. On evaporating this solution, there remained a dark-coloured residue consisting in great part of hydrochlorate of glycocine; it was dissolved in water, boiled with hydrated oxide of lead till no more ammonia was evolved, the lead precipitated from the filtrate by sulphuretted hydrogen, the liquid mixed with sulphuric acid, and evaporated in the water-bath. The residue was treated with absolute alcohol, when sulphate of glycocine, together with a little sulphate of soda, remained behind; the alcoholic solution, on addition of bichloride of platinum and hydrochloric acid, gave a bright yellow flocculent precipitate which dissolved easily in water, and crystallised from the solution in needles upon addition of alcohol. The substance here in combination with bichloride of platinum is a powerful organic base. By treating the platinum double-salt with sulphuretted hydrogen, evaporating the solution with sulphuric acid, and decomposing the sulphate with carbonate of baryta, indistinct crystals were obtained which burnt entirely away, had an alkaline reaction, and evolved carbonic acid on addition of hydrochloric acid. All the salts of this base are soluble in water, the majority of them also in alcohol. The base contains sulphur which is not indicated by oxide of lead.

Strecker has, moreover, examined the products of the decomposition of hyocholic acid by hydrochloric acid and by alkalis. He found that by boiling pure hyocholic acid with concentrated hydrochloric acid which was constantly renewed, the resinous mass became gradually less liquid, and after several days' boiling solidified in the boiling acid. This product, corresponding to the dyslysin of ox-

bile, is no longer soluble in alcohol; it was purified as far as possible by solution in ether and reprecipitation by alcohol. Dried at  $120^{\circ}$  its composition was expressed by the formula  $C_{50}H_{38}O_6$  (found 77.61 carbon, and 9.97 per cent hydrogen; calculated 77.72 per cent carbon and 9.84 hydrogen); it, therefore, stands to the dyslysin of ox-bile in the same relation in which hyocholic acid stands to cholonic acid, since it contains  $C_2H_2$  more. The hydrochloric solution contains glycocine which separates on evaporation as a brown crystalline mass; if this mass be dissolved in water, the boiling solution treated with hydrated oxide of lead, and the lead removed from the filtrate by sulphuretted hydrogen, the glycocine may be obtained in pure crystals; the identity of this substance with glycocine was proved by the analysis of the substance itself, and of its combination with oxide of copper. Hyocholic acid, therefore, when boiled with hydrochloric acid, is decomposed into glycocine and the substance corresponding to dyslysin ( $C_{54}H_{43}NO_{10} = C_{50}H_{38}O_6 + C_4H_5NO_4$ ). — If hyocholic acid be dissolved in a dilute solution of potassa, and the solution boiled for a long time, the evaporated water being allowed to return, decomposition takes place; on adding hydrochloric acid to the liquid after twenty-four hours boiling, a resinous substance separates which is washed with water and dissolved in ether; from this solution it separates by slow spontaneous evaporation, in small roundish white crystals. Strecker (alluding to the cholalic acid produced by the action of alkalis upon cholic acid [see Vol. II, page 180, of the last Annual Report]) has designated this substance *hyocholalic acid*. This acid dissolves easily in alcohol, less easily in ether, and is almost insoluble in water; from the alcoholic solution it separates on evaporation as an amorphous mass, but upon addition of water, especially if the alcoholic solution contains a little ether, it is frequently obtained in small crystals (appearing under the microscope as six-sided tables). It dissolves easily in dilute solutions of caustic or carbonated alkalis; on addition of a concentrated solution of hydrate or carbonate of potassa, the potassa-salt is again separated. The solution in ammonia gives with salts of lime and baryta, as well as with the solutions of most heavy metallic oxides, flocculent precipitates. The baryta-salt was still farther purified by solution in alcohol and evaporation; it is difficult of solution in water, the solution has a bitter taste, and is precipitated by acids and by acetate of lead.

	Carbon.			Hydrogen.			Nitro- gen.	Ba- ryta.
<i>Acid</i> (dried at $120^{\circ}$ ), found . . . . .	74.5	74.1	74.2	9.9	10.0	10.3	—	—
Calculated as $C_{50}H_{38}O_6$ . . . . .	74.3			9.9			15.8	—
<i>Baryta-salt</i> (dried between $120^{\circ}$ & $160^{\circ}$ ) . . . . .	62.3	62.2	62.3	8.4	8.4	8.4	—	15.9
Calculated as $BaO, C_{50}H_{40}O_8$ . . . . .	62.4			8.3			13.3	15.9
(dried at $200^{\circ}$ ) . . . . .	63.1			8.5			—	15.9
Calculated as $BaO, C_{50}H_{38}O_7$ . . . . .	63.6			8.3			11.9	16.2

The baryta-salt which had been dried between  $130^{\circ}$  and  $160^{\circ}$ , lost

**Pig's bile.** 1 equiv. more water between  $180^{\circ}$  and  $200^{\circ}$ , without suffering any alteration of form or colour (found 1.4 and 1.8 per cent, calculated 1.8 per cent); the hyocholic acid contained in the salt does not appear to undergo any change at this temperature. The formula of the dry salts, therefore, appears to be  $\text{RO}$ ,  $\text{C}_{50}\text{H}_{39}\text{O}_7$ , and 1 equiv. of water in the hyocholic acid is replaced by a base. The following equation represents the decomposition of hyocholic acid into hyocholic acid and glycocine:  $\text{C}_{51}\text{H}_{43}\text{NO}_{10} + 2\text{HO} = \text{C}_{50}\text{H}_{40}\text{O}_8 + \text{C}_4\text{H}_5\text{NO}_4$ .

**Dog's Bile.**—According to Strecker, the residue obtained by evaporating the fresh bile of dogs dissolves, for the most part, in alcohol, and is precipitated from the solution by ether in the form of amorphous, slightly coloured flakes, which become crystalline when allowed to remain for some time in contact with the liquid, or more rapidly when treated with fresh ether. The precipitate, when decomposed by alkalis, yields cholic acid and taurin apparently unmixed with a trace of glycocine; when dried at  $120^{\circ}$ , it exhibits the composition of choleate of soda  $\text{NaO}$ ,  $\text{C}_{52}\text{H}_{41}\text{NS}_2\text{O}_{13}$  (found, 58.2 per cent carbon, 8.2 hydrogen, 5.9 sulphur, and 10.8 ash, which, after treatment with sulphuric acid, weighed 13.4), nearly corresponding also in composition with the bile of *Boa anaconda* analysed by Schlieper(1). The properties of the bile of the dog appear to be independent of the nature of its food.

**Sheep's Bile.**—The bile of sheep, when decomposed by alkalis, yields cholic acid, taurin, and slight traces of glycocine; it is more highly coloured than that of the dog, and its colouring matter appears to be identical with that contained in ox-bile; sheep's bile is a mixture of much choleate and a little cholate of soda.

**Fish-bile.**—Strecker has, moreover, examined the bile of different kinds of fish; the specimens were furnished to him by De Vry of Rotterdam, who collected the bile and evaporated it to dryness on a water-bath. The bile of the turbot (*Pleuronectes maximus*, L., *Rhombus maximus*, Cuv.), that of the cod (*Gadus Morrhua*), of the pike (*Esox lucius*), and the perch (*Perca fluviatilis*) exhibit very similar properties. When the dried bile was treated with absolute alcohol, mucus of the gall-bladder, together with some colouring matter, remained undissolved; from the brown alcoholic solution, a little ether precipitated almost all the colouring matter together with a small portion of the other constituents of the bile; the greater part of the latter was precipitated by adding much ether, the ethereal solution then concentrated, and the precipitation by ether repeated; on evaporating the ethereal liquid, crystals of cholesterin were obtained, together with some oily drops. When the amorphous precipitate obtained on addition of ether was allowed to remain for some time exposed to the air, it was converted into a mass of crystals

similar in appearance to wavellite; it consisted almost entirely of choleic acid, the sulphurised constituent of ox-bile. When decomposed with baryta, it furnished cholalic acid and taurin, the identity of which, with the products of decomposition obtained from the choleic acid of ox-bile, was satisfactorily demonstrated (together with taurin, a small quantity of glycocine appeared also to be formed). It was farther proved by the analysis of the potassa-salt prepared from the bile of *Pleuronectes maximus*, that the fish-bile consisted almost entirely of salts of choleic acid. The bile (freed from other substances by means of alcohol and ether) was dissolved in water and mixed with a concentrated solution of pure potassa; the salt thus separated was dissolved in absolute alcohol, the excess of potassa precipitated by carbonic acid, and the potassa-salt separated from the solution by ether; the composition of this salt very nearly coincided with that of pure choleate of potassa.—The subjoined table exhibits the composition, according to Strecker, of 100 parts of bile which had been purified by solution in alcohol, precipitation with ether, and drying between 120° and 130° (the numbers enclosed in parentheses represent the weight of the ash after moistening with sulphuric acid and igniting); the composition of the bile is here compared with that of the choleate and cholate of potassa and soda.

	Gadus Morhua.	Pleuro- nectes maximus.	Esox lucius.	Perea fluvia- tilis.	Choleate of		Cholate of	
					potassa.	soda.	potassa.	soda.
Carbon .	56.1	56.2	59.4		56.4	58.1	62.0	64.1
Hydrogen .	8.1	8.0	8.3		8.0	8.2	8.3	8.6
Sulphur .	5.7	5.9	5.8	6.0	5.8	6.0	—	—
Ash . .	12.6 (14.5)	14.6 (17.1)	11.8 (13.9)	11.4 (14.1)	Base: 8.5 (15.7)	5.8 (13.2)	9.4 (17.3)	6.4 (14.6)

In the two first cases the choleate of potassa preponderates, in the two last there is a larger proportion of soda, part of which, in the bile of *Esox lucius*, is combined with cholic acid. Upon this subject, Strecker observes that in the bile of sea-fish which live in a medium so rich in sodium, potassa predominates, whilst in the bile of oxen, the food of which abounds in potassa, only traces of the latter are found, associated with a large quantity of soda.

**Bile of Geese.**—Marsson(1) found, on an average, in the bile of geese fed with oats, 0.36 per cent fat and cholesterin, 2.56 mucus (which contained 7.12 per cent phosphate of lime), 17.06 biliary matter and colouring matter (soluble in alcohol and insoluble in ether), and 80.02 water.—The quantity of bile contained in the gall-bladder of a goose (average weight 16 Prussian pounds) was, on an average, 3 grms; the dark-green bile had an acid reaction. 100

(1) Arch. Pharm. [2] LVIII, 138; Ann. Ch. Pharm. LXXII, 317.



Bile of  
geese.

parts of the dried bile gave from 1.05 to 2.08 of ash which effervesced with acids, and contained chlorine, phosphoric acid, sulphuric acid, soda and magnesia. In that portion of the bile which was soluble in alcohol and insoluble in ether, when decolorised as far as possible by blood charcoal, and dried at 110°, Marsson found 57.2 per cent carbon, 8.4 hydrogen, 3.5 nitrogen, 6.2 and 6.5 sulphur, and 4.8 soda (9.6 ash), a composition similar to that assigned by Bensche(1) to the bile of hens. This portion of the bile crystallises from an alcoholic solution, on addition of ether, in microscopic, rhombic tables, and is precipitated by chloride of calcium, chloride of barium, and hydrochloric acid; Marsson supposes it to contain a peculiar sulphurised acid, for which he proposes the name *chenocholic acid* (χέν, χηρός, a goose).

**Cholesterin.**—Zwenger(2) has investigated the action of phosphoric acid upon cholesterin, and finds the products of decomposition similar to those obtained at an earlier period(3) by the action of sulphuric acid.—When one part of cholesterin is heated with six or eight parts of concentrated phosphoric acid, fusion and decomposition of the former take place when the temperature has risen to 137°. If the temperature be not farther increased, nor the fusion continued for too long a time, the decomposed mass contains two hydrocarbons, the one, *a cholesterone*, being present in considerable quantity, the other, *b cholesterone*, in small quantity together with a small amount of a resinous substance.—*a cholesterone* may be obtained from the mass after washing with water, by boiling it repeatedly with alcohol, and crystallises from this solution in fine long needles which are purified by recrystallisation. The first solution obtained by boiling with alcohol contains phosphoric acid, and should therefore be set aside. It forms lustrous, right rhombic prisms, terminated by dihedral summits; these crystals were colourless; their analysis furnished, as a mean result, 87.7 per cent carbon and 12.1 hydrogen. This substance is insoluble in water, easily soluble in ether and in the fixed and volatile oils. It fuses at 68° to a liquid which but slowly solidifies again on cooling; at a higher temperature it distils almost unchanged; it burns with a smoky flame, and is decomposed by chlorine and nitric acid.—The residue from which the *a cholesterone* has been extracted, is boiled with ether; the ethereal solution by cooling and spontaneous evaporation, deposits *b cholesterone* as a white crystalline mass which is scarcely soluble in alcohol, insoluble in water, but dissolves easily in fixed and volatile oils; *b cholesterone* on es at about 175°, and at higher temperatures distils over with taincel decomposition; it burns with a smoky flame, and contains pitate  
time ex

Annual Report for 1847 and 1848, II, 191.

Ch. Pharm. LXIX, 347.

Report for 1847 and 1848, II, 194.

87·7 per cent carbon and 12·0 hydrogen. In their composition, therefore, both these substances resemble or coincide with the products obtained by the action of sulphuric acid upon cholesterin; they differ, however, from these last in their fusing points. The resinous substance above alluded to is formed in larger quantity when the heat is too great or is continued for too long a period; like the other products, it is probably a hydrocarbon. — Zwenger considers the facility with which cholesterin is decomposed, with separation of water, by moderately strong acids, as an argument in favour of the view which regards cholesterin as the hydrate of a hydrocarbon  $C_{81}H_{66} + 3 HO$ .

**Biliary Calculi.**—Sthamer(1) has examined three biliary calculi according to the method employed by Hein(2), and has assigned to them the following percentage-composition:

	1.	2.	3.
Spec. grav. . . . .	1·046	1·096	1·056
Loss on drying . . . . .	2·55	1·69	5·38
Ash . . . . .	1·29	2·48	0·63
Substances soluble in water and loss . . . . .	8·61	4·21	7·85
Substances soluble { Cholesterin . . . . .	75·92	83·60	66·89
{ in alcohol . . . . .	8·85	2·59	6·38
Residue . { Soluble in ammonia . . . . .	0·67	0·28	1·61
{ Insoluble in ammonia . . . . .	2·11	5·15	11·26

The ash of 1, contained earthy phosphates, with traces of iron, carbonate of lime and soda-salts; that of 2, carbonate of lime; that of 3, lime- and soda-salts, with traces of copper.

Th. Anderson(3) found that concretions which came into his possession as “biliary calculi of a cow,” of the origin of which, however, he could not speak with certainty, were composed of 86·6 per cent carbonate of lime, and 13·4 animal matter; they resembled pearl in appearance and structure.

**Milk.**—R. F. Marchand(4) has examined the sanguiferous milk of a cow. We can only find space for the results of one of his protracted observations. The dark-brown, viscous milk had the sp. gr. 1·092, coagulated on heating, and on addition of alcohol, like blood, and yielded 29·24 per cent of residue dried at 120°, which contained 1·75 fat, 5·14 sugar, 2·20 casein, 15·00 albumin, 0·20 fibrin, 4·95 hæmatin, and other substances. No blood-corpuscles could be detected in this milk.

Gorup-Besanez(5) has determined the composition of goat's milk drawn in the morning (A), of the same in the evening, (B), before etherisation (C), directly after etherisation of the animal (D),

(1) Arch. Pharm. [2] LIX, 159.

(2) Annual Report for 1847 and 1848, II, 193.

(3) Monthly Journ. of Med. Soc. XXIX (1848); Schmidt's Jahrbücher d. Ges. Medicin LXII, 277.

(4) J. Pr. Chem. XLVII, 129.

(5) Griesinger's Archiv für Physiol. Heilk. VIII, Jahrg., 717.

Milk.

and two hours later (E). He moreover examined the milk of a nurse suffering from icterus (F) (biliary colouring matter is said to have been present in this milk). The method employed was that of Haidlen(1).

	A.	B.	C.	D.	E.	F.
Water . . . . .	872.4	822.5	856.1	846.4	860.3	906.6
Casein . . . . .	46.2	43.1	48.4	43.3	31.3	90.8
Butter . . . . .	37.6	93.8	60.3	73.6	69.0	
Sugar and extractive matter . . . . .	43.8	40.5	35.1	36.7	39.4	
Salts . . . . .	8.9	8.2	8.9	9.4	8.1	2.6

**Ashes of Milk.**—H. Rose(2) has communicated an analysis made according to his method, by R. Weber, of the ashes of un-skimmed cow's milk(3). The aqueous solution of the evaporated and carbonised milk left 7.125 grms. of residue, of the percentage-composition A; the hydrochloric solution left 6.621 grms. of the composition B; the charcoal, after exhaustion with water and hydrochloric acid, gave 7.109 grms. of ash of the composition C. From these numbers, the percentage-composition of the entire ash is calculated as at D.

	A.	B.	C.	D.
Chloride of potassium . . . . .	41.42	—	—	14.18
Chloride of sodium . . . . .	13.85	—	—	4.74
Potassa . . . . .	29.66	6.29	33.13	23.46
Soda . . . . .	—	12.19	9.01	6.96
Lime . . . . .	—	36.70	16.58	17.34
Magnesia . . . . .	—	3.26	3.40	2.20
Sesquioxide of iron . . . . .	—	0.30	1.10	0.47
Phosphoric acid . . . . .	7.25	41.26	36.60	28.04
Sulphuric acid . . . . .	0.17	—	—	0.05
Carbonic acid . . . . .	7.27	—	—	2.50
Silica . . . . .	—	—	0.18	0.06

**Urine.**—Bence Jones(4) found that the acid reaction of healthy urine was subject to considerable variation; the acid reaction is strongest before eating, and weakest some time afterwards; it is independent of the amount of uric acid present in the urine. The acidity is increased by the administration of tartaric acid, and of large quantities of diluted sulphuric acid; it is not always lessened by diluted solution of potassa, but rapidly (as had been previously shown) by tartrate of potassa. The use of any food, no matter whether animal or vegetable, increases the amount of uric acid in the urine. The amount of sulphates present in the urine is increased by the administration of large quantities of diluted sulphuric acid, of sulphur, and especially of the sulphates of soda and magnesia.

(1) Ann. Ch. Pharm. XLV, 273.

(2) Pogg. Ann. LXXVI, 390; J. Pr. Chem. XLVIII, 59; Phil. Mag. [3] XXXV, 279.

(3) Annual Report for 1847 and 1848, II, 237; see the present Report upon Analytical Chemistry.

(4) Phil. Mag. [3] XXXIV, 311; XXXV, 152; Chem. Gaz. 1849, 248, 267; Instit. 1849, 160.

The urine of calves of three or four weeks possesses, according to Wöhler(1), a strongly acid reaction even after evaporation; it contains urea and uric acid, apparently in the same quantities as healthy human urine; when concentrated, it gives with nitric acid, a pasty mass of nitrate of urea, and after some time a small quantity of a blue powder, the same, probably, which has been sometimes observed in blue human urine. This urine contains very much phosphate of magnesia, large quantities of chloride of potassium, and, a large quantity of salts of potassa with little or no salts of soda, no hippuric acid, but in its stead, allantoin (compare page 354), whilst cow's urine, which is rich in hippuric acid, contains no allantoin.

Bernard(2) observed that after wounding a certain portion of the fourth ventricle of a rabbit (somewhat above the origin of the eighth pair of nerves), the urine becomes, after one or two hours, clear and saccharine, and sugar also makes its appearance in the blood.

Begbie(3) has communicated some facts respecting the reactions of urine containing oxalate of lime, and Walshe(4), upon the occurrence of oxalate of lime in the urine in various diseases.

Sthamer(5) has examined the urine of a person suffering from Bright's disease which terminated in phthisis. During the first days of the disease the urine was turbid, acid, of sp. gr. 1·020, contained 0·84 per cent albumin, a greater relative quantity of urea without diminution of the uric acid, and coagulated strongly when heated. At a later period of the disease the sp. gr. sank to 1·014, and the albumin was diminished to 0·62 per cent. Lastly, the sp. gr. of the urine again rose to 1·020, it was no longer coagulated by heat alone, but when warmed, after addition of a few drops of acetic acid, formed a viscid mass.—Walz(6) has examined the urine of a child suffering from diabetes mellitus (A that passed during the night, sp. gr. 1·036, and B that passed during the day, sp. gr. 1·033), and gives the following as the composition of 1000 parts (we have not prejudiced the accuracy of the results by the omission of three decimal places calculated by Walz in addition to those given in the table).

	A.	B.		A.	B.
Chloride of potassium .	0·67	0·64	Mucus of the bladder .	trace	trace
Chloride of sodium .	0·79	0·76	Urea . . . . .	6 27	6·21
Chloride of ammonium .	trace	trace	Albumen . . . . .	trace	trace
Phosphate of lime .	0·65	0·65	Sugar . . . . .	77·56	77·08
Phosphate of magnesia . }			Colouring matter of the }	0·30	0·31
Sulphate of lime . . .	0·39	0·37	urine . . . . . }		
Uric acid . . . . .	0·10	0·10	Silica . . . . .	0·08	0·05
Carbonic acid . . . .	0·27	0·27	Water . . . . .	912·93	913·57

(1) Loc. cit. p. 354.

(2) Compt. Rend. XXVIII, 393; Chem. Gaz. 1849, 198.

(3) Monthly Journ. of Med. Soc., March, 1848; Schmidt's Jahrb. d. Ges. Medicin LXII, 6.

(4) J. Chim. Méd. [3] V, 230.

(5) Arch. Pharm. [2] LIX, 163.

(6) Jahrb. Pr. Pharm. XIX, 267.

Urine.

Gorup-Besanez(1) has published copious numerical results with regard to the composition of the urine in various diseases; since the occurrence of certain substances in the urine under particular conditions is not a result deducible from this investigation, we must content ourselves with referring to the original treatise.

Millon(2) is of opinion that the ultimate analysis of animal fluids must be effected upon the fluid itself without previous evaporation, and has endeavoured to determine, upon this principle, the amount of nitrogen contained in the urine. In an experiment made upon a rabbit fed during ten days with cabbage (in the different parts of which, in the fresh state, Millon found 0.42 to 0.62 per cent nitrogen), the urine passed during two days contained 0.6 per cent nitrogen, whilst that passed during two following days contained 0.49; in the solid excrements (not dried) the amount of nitrogen was constant at 1.43 per cent. When the animal was fed for thirteen days with carrots (the nitrogen contained in the different parts of which, Millon found to vary between 0.01 and 0.16 per cent, that contained in the whole carrot being 0.2 per cent), the urine of two days contained 0.17 per cent nitrogen; that of two following days 0.16, and that of the next two days 0.08. Equally considerable variations were observed when the animal was fed upon a mixed diet of cabbage, carrots and bread; in successive periods of two days, Millon found 0.26, 0.52 and 0.30 per cent of nitrogen in the urine.

**Hyraceum Capense.**—Reichel(3) has examined the dried residue (known as *Dasjes-pis* or *Hyraceum capense*) of the urine of the *Hyrax capensis*, and has published the following hyper-accurate analysis of it:

Albumin . . .	0.083	Lime . . .	2.816	Thick yellow volatile oil . . .	0.666
Uric acid . . .	0.833	Magnesia . . .	2.600	Yellow fat . . .	0.250
Benzoic acid . . .	1.500	Potassa . . .	22.500	Benzoin-like resin . . .	1.750
Hippuric acid . . .	3.166	Soda . . .	15.433	Bitter brown extractive matter . . .	22.500
Melanic acid . . .	4.166	Ammonia . . .	1.666	Hairs and fibres . . .	0.355
Sulphuric acid . . .	0.500	Urea . . .	2.173	Moisture . . .	5.333
Hydrochloric acid . . .	1.316	Castorin . . .	0.166	Carbonic acid and loss . . .	8.978
		Sand . . .	1.250		

Concerning the mode of combination of the various acids and bases which are here given, Reichel has not informed us; the absence of phosphoric acid has also been left without explanation.

**Urine and Fæces.**—The average composition by weight of the solid and liquid excrements has been deduced from the five series

(1) Griesinger's Archiv f. Physiol. Heilk. VIII, 708.

(2) Compt. Rend. XXIX, 595. Millon states that in the evaporation of urine, from  $\frac{1}{4}$  to  $\frac{1}{2}$  of the nitrogen is evolved. For a discussion regarding a question of priority in the analysis of animal liquids between Millon, Boussingault and Payen, we refer to Compt. Rend. XXIX, 605, 705, 706.

(3) Arch. Pharm. [2] LIX, 40.

of experiments conducted by Barral(1), and mentioned at page 360; (the weights are all expressed in grammes) :

Urine and  
faeces.

	Water.	Dry organic substance.				Chlo- rine.	Inor- ganic salts.	Total weight.
1. Urine	1071.5	37.0 (15.1 C; 3.0 H; 10.9 N; 8.0 O)				4.9	9.6	1123
· Faeces	106.3	29.4 (15.3 „ 2.3 „ 2.8 „ 8.9 „)				0.1	5.8	142
2. Urine	978.0	33.6 (13.7 „ 2.8 „ 9.8 „ 7.2 „)				3.8	8.6	1024
Faeces	54.8	17.1 ( 8.9 „ 1.3 „ 1.3 „ 5.6 „)				0.0	3.5	75
3. Urine	504.8	10.7 ( 4.4 „ 0.9 „ 3.1 „ 2.3 „)				1.9	3.2	529
Faeces	62.4	18.7 ( 9.8 „ 1.5 „ 1.8 „ 5.7 „)				0.0	2.8	84
4. Urine	1723.0	51.9 (21.2 „ 4.3 „ 15.2 „ 11.2 „)				3.4	8.9	1787
Faeces	142.7	26.5 (13.8 „ 2.1 „ 2.5 „ 8.1 „)				0.1	6.4	176
5. Urine	1112.4	34.1 (13.9 „ 2.8 „ 10.0 „ 7.4 „)				3.1	6.8	1156
Faeces	25.8	8.1 ( 4.2 „ 0.6 „ 0.8 „ 2.5 „)				0.0	1.2	35

In connection with this subject, Barral(2) has, moreover, endeavoured to ascertain how the composition of the excrements is affected by the consumption of common salt. The experiments were tried upon a sheep which was supplied with salt; during the first five days (A) of the experiment, 12 grms. of common salt were each day excreted by the animal; during the succeeding 10 days no salt was obtained, which was also the case during the following four days (B); the salt then again made its appearance (being excreted to the amount of 8 grms. daily) during seven days, and continued to be excreted during the succeeding four days(C). The use of common salt appeared to augment the amount of nitrogen and of urea in the excrements.

	A.	B.	C.
Nitrogen per cent of the dried excrements (calculated as if free from ash)	24.51	9.83	17.47
Average amount of nitrogen excreted daily (in grms.)	5.69	1.68	3.55
Urea per cent of the dried organic portion of the excrements	40.57	16.60	29.54
Average amount of urea excreted daily (in grms.)	9.42	2.84	6.03

The use of salt was also productive of an increase in the amount of the urine, and in that of the uric acid which it contained.

**Ashes of Urine and Faeces.**—J. A. Porter(3) has examined the ashes of human excrements. The ash of the urine of four days (after deducting the carbon) weighed 57.50 grms.; the ash of the faeces during the same period (after deducting the carbon and sand) amounted, on an average, to 6.7 per cent. He gives the composition of the ash in 100 parts as follows:

	KO.	NaO.	CaO.	MgO.	Fe <sub>2</sub> O <sub>3</sub> .	PO <sub>5</sub> .	SO <sub>3</sub> .	CO <sub>2</sub> .	NaCl.
Faeces	6.10	5.07	26.46	10.54	2.50	36.03	3.13	5.07	4.33
Urine	13.64	1.33	1.15	1.34	tracc	11.21	4.06	—	67.26

(1) Loc. cit. p. 521.

(2) Compt. Rend. XXIX, 419; Instit. 1849, 330.

(3) Ann. Ch. Pharm. LXXI, 109.

Ashes of  
urine and  
fæces.

Porter has, moreover, compared the composition of the two ashes, *minus* the chloride of sodium, in the proportions in which they were present in the excrements from which they were respectively derived. He finds that (after deducting the chloride of sodium and the excess of lime and sulphuric acid in the ashes of the excrements) a remarkable correspondence exists in the relative proportions of the inorganic constituents present in the food, and of those in the excrements; a similar coincidence was observed in the juice of flesh, the blood, and the urine.

H. Rose(1) has communicated an analysis made according to his method(2) by Fleitmann, of the ashes of the fæces and urine of a young man. The aqueous extract of the carbonised fæces left behind 1·933 grms. of residue of the percentage composition A; the hydrochloric extract left 6·493 grms. of residue of the composition B; the coal exhausted with water and hydrochloric acid gave 1·996 grms. of ash of the composition C; the composition of the entire ash is hence calculated as at D (Rose accounts for the exceedingly large quantity of sand from the young man's habit of taking walks in the neighbourhood of Berlin). A (weighing 54·148 grms.), and B (weighing 5·085 grms.), have a similar signification to that above assigned to them, with regard to the analysis of the ash of the urine; the ash of the coal exhausted with water and hydrochloric acid (and which weighed only 0·352 gm.) contained silica (44·32 per cent), and the remainder consisted almost entirely of phosphate of magnesia.—E and F furnish respectively the weight in grammes of the salts daily excreted in the urine and in the fæces.

	Fæces.				Urine.		Urine.	Fæces.
	A.	B.	C.	D.	A.	B.	E.	F.
Chloride of sodium .	3·15	—	—	0·58	62·78	—	8·924	0·017
Chloride of potassium .	0·37	—	—	0·07	9·89	—	0·751	—
Potassa .	27·81	10·22	4·83	12·44	15·40	2·96	2·482	0·546
Hydrate of potassa* .	54·18	—	—	10·05	—	—	—	—
Soda .	—	1·06	0·42	0·75	—	19·22	—	0·019
Lime .	—	31·32	9·66	21·36	—	17·66	0·225	0·557
Magnesia .	—	13·98	10·24	10·67	0·32	13·65	0·242	0·278
Sesquioxide of iron .	—	1·32	6·61	2·09	—	0·38	0·005	0·054
Phosphoric acid .	6·75	41·69	19·61	30·98	8·92	41·51	1·760	0·807
Sulphuric acid .	1·57	0·18	3·77	1·13	2·69	1·86	0·386	0·029
Silica .	0·52	—	6·25	1·44	—	2·76	0·069	0·038
Carbonic acid .	5·65	0·23	—	1·05	—	—	—	—
Sand .	—	—	38·61	7·39	—	—	—	—

\* Or the equivalent weight of carbonate of potassa.

Total 14·844 | 2·343

(1) Pogg. Ann. LXXVI, 376; J. Pr. Chem. XLVIII, 52; Phil. Mag. [3] XXXV, 273.

(2) Annual Report for 1847 and 1848, II, 237; see the present Report upon Analytical Chemistry.

**Urinary and other Concretions.**—Sthamer(1) has examined a urinary calculus (A) from a man (its sp. gr. was 1·014); Schlossberger(2), a calculus (B) from the enlarged right *vena vesicalis* of a man; Moride(3) has analysed some needle-like crystalline concretions excreted from the rectum of a man (he found in 13 parts, 5 parts of animal matter, 6 of phosphate of lime, 1 of carbonate of lime formed from the oxalate, and 1 of soluble alkaline salts, magnesia and loss). T. J. Herapath(4) has examined a fatty substance which was contained in an ovarian cyst; he found in it 84·69 per cent elain (only partly soluble in hot ether), 11·68 margarin, 1·24 extractive matter and chloride of sodium, and 2·39 of epidermoid cells and hair; this substance gave 0·83 per cent ash, containing carbonic, phosphoric, sulphuric and silicic acids, chlorine, soda, lime, magnesia and some iron.—Herapath(5) has, moreover, examined a calculus (C) from the liver of an ape; Girardin(6) has analysed concretions (D) from the urinary bladder of an ox (their specific gravity varied between 1·001 and 1·009). Chevreul(7) found, in a calculus taken from the kidney of an ox, carbonate of lime, carbonate of magnesia, phosphate of lime, phosphate of magnesia-ammonia, silica, traces of potassa- and soda-salts, together with nitrogenised organic matter, phosphorised fat (from the blood), and a dark-coloured organic substance. Landerer(8) has described the hardened glandular swelling of an ass. Winckler(9) has made some experiments upon the lithofellic acid contained in bezoar-stones; he found it very similar to chinovasic acid, and proposes for it the name *lithamaric acid*.

	A.	B.	C.	D.
Phosphate of lime . . . . .	24·16	50·1	18·8	12·0
„ magnesia . . . . .	—	13·7	trace	—
„ magnesia-ammonia . . . . .	52·68	—	—	—
„ sesquioxide of iron . . . . .	—	—	trace	—
Carbonate of lime . . . . .	8·25	8·3	13·6	51·0
„ magnesia . . . . .	1·11	—		9·8
Chloride of sodium . . . . .	—	—	trace	trace
Oxalate of lime . . . . .	1·29	—	—	—
Urate of soda . . . . .	4·08	—	—	—
Organic matter . . . . .	—	20·4	—	—
Nitrogenised matter . . . . .	1·50	—	—	13·0
Fat . . . . .	0·38	—	35·6	—
Albumin . . . . .	—	—		—
Water . . . . .	5·96	6·1	little	14·2

(1) Arch. Pharm. [2] LIX, 279.

(2) Ann. Ch. Pharm. LXIX, 255.

(3) J. Chim. Méd. [3] V, 623.

(4) Chem. Gaz. 1849, 113.

(5) Chem. Gaz. 1849, 362.

(6) J. Pharm. [3] XV, 169; J. Chim. Méd. [3] V, 312; J. Pr. Chem. XLVII, 410.

(7) J. Pharm. [3] XVI, 196.

(8) Arch. Pharm. [2] LIX, 284.

(9) Jahrb. Pr. Pharm. XVIII, 376.



Liquid  
from a  
cyst con-  
taining  
echyno-  
cocci.

**Liquid from a Cyst containing Echynococci.**—Heintz(1) has examined the liquid from a hydatid cyst which had been formed in the liver of a woman. The colourless liquid had sp. gr. of 1·0076; it contained only traces of phosphoric acid, but an acid which appeared to be identical with succinic acid. Heintz found in 1000 parts, 0·46 chloride of calcium, 0·20 chloride of magnesium, 0·24 chloride of potassium, 3·85 chloride of sodium, 3·41 succinate of soda, 5·08 extractive matter, and 986·76 water.

**Liquid from a Mola Hydatidea.**—In 1000 parts of the fluid from the cysts of a *mola hydatidea*, H. Heller(2) found 974·8 water, 14·4 albumin, a little hæmugin, a substance similar to mucus, extractive matter and saponified fat; 2·4 free saponifiable fat; 4·2 chloride of sodium, 3·0 carbonate of soda, sulphate of potassa and earthy phosphates, 1·0 basic phosphate of soda, and traces of iron.

**Fluids from Cholera-patients.**—Cörenwinder(3) has examined the fluid secretions and excretions of cholera-patients, and infers from his experiments that a considerable quantity of albumin(4) is contained in the intestinal fluids (A); the evacuations (B) contain but a small quantity of solid matter, little or no albumin, and much chloride of sodium; in the blood (C) the amount of solid matter is said to be increased, whilst that of the chloride of sodium is diminished (to even  $\frac{1}{5}$  of the normal quantity); the composition of the serum suffers no perceptible alteration. There were found in 100 parts:

	A.	B.			C.			
Water . . . .	87·00	98·76	98·96	98·18	75·33	75·11	75·11	71·00
Albumin . . . .	9·56	0·28	0·00	0·09	?	?	?	?
Chloride of sodium .	0·53	0·38	0·28	0·50	0·19	0·28	0·21	0·07

Güterbock(5) assigns to the intestinal evacuations of cholera patients, the percentage composition given in the columns from 1 to 5 in the following table; 6 shows the composition of the liquid taken from the small intestine after the death of the patient; in 7, 8 and 9, is given the composition of the vomited liquid; [10 exhibits the composition of the liquid vomited in a case precisely similar to that described, according to A. S. Taylor(6)]. (The substances included under the term "other salts" are the phosphates of lime

(1) Jenaische Ann. f. Physiol. u. Med, I, 180; Pogg. Ann. LXXX, 114 (in which last place, the identity of the acid in question with succinic acid is confirmed by analysis).

(2) Heller's Archiv für Physiol. und Pathol. Chem. und Mikrosk. IV; Schmidt's Jahrb. d. Ges. Medicin LXIII, 273.

(3) Compt. Rend. XXVIII, 233; Instit. 1849, 49.

(4) The analysis A is only to be taken in the sense here indicated; in the original paper the composition of the serum is carefully stated.

(5) J. Pr. Chem. XLVIII, 340.

(6) From the London Med. Gaz., Febr. 1849, in the Chem. Gaz. 1849, 95.

and of magnesia, carbonate of soda and traces of alkaline sulphates. Albumin was found in considerable quantity in 6, but none at all, or only a trace, in the other cases.

Fluids in  
cholera-  
patients.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Water . . . . .	97·41	98·65	98·40	99·03	98·90	98·12	99·05	99·65	99·58	96·7
Organic constituents	0·59	0·08	0·13	0·12	0·29	0·92	0·39	0·12	0·25	2·5
Chloride of sodium .	1·15	0·43	0·39	0·62	0·45	0·70	0·28	0·09	0·17	} 0·8
Other salts . . . .	0·85	0·84	1·08	0·23	0·36	0·25	0·28	0·14	0·09	

Güterbock concludes from these analyses that the intestinal evacuations in cholera are very rich in water and in inorganic constituents (especially in chloride of sodium), and poor in organic matter. —He found that the bile contained more than the normal amount of water, and could not succeed in detecting urea in the blood.

According to Doyère(1), the viscid sweat (but this only) of cholera patients, contains a substance capable of effecting the reduction of the oxide of copper in the potassa-tartrate (Barreswil's liquid for the sugar-test); this statement has been confirmed by Poirson(2)

(1) Compt. Rend. XXIX, 221; Inst. 1849, 265.

(2) Compt. Rend. XXIX, 422.

# ANALYTICAL CHEMISTRY.

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Calculation of analyses.

**Calculation of Analyses.**—Einbrodt(1) has endeavoured to show that in calculating the atomic weight of a substance A from several analyses of its combination with another substance B of known atomic weight, a more accurate mean is obtained when the percentage composition is calculated from each analysis, and from the mean of these numbers, the atomic weight of A deduced, than when the atomic weight is calculated from each analysis, and the mean of these results taken as the truth.—In order to determine how far the formula of any substance agrees with the results obtained by analysis, Einbrodt(2) recommends that the percentage amount of each constituent calculated from the analysis, should be divided by the product of the number of atoms of this constituent, indicated by the formula, into its atomic weight; the more nearly the result of the analysis coincides with the formula, the more closely will these numbers correspond among themselves, and with the normal quotient (100 divided by the atomic weight represented by the formula of the substance analysed).

**Analysis of Gases.**—Regnault and Reiset(3), incidentally to their researches upon the respiration of animals, have made some important observations upon the analysis of gases. The apparatus which they employ in this branch of analysis, consists essentially of the following parts: an U-shaped tube, provided at the lowest part of the curve with a stop-cock A, and having the longer limb B open, whilst the shorter limb C is connected at its upper extremity, by means of a capillary tube (the communication through which may be cut off at D by several stop-cocks), with a bell-jar E standing in a mercury-trough. The trough F is fixed, but the rest of the apparatus may be raised and lowered by means of a rack and spring. The gases are mixed in the jar E, where also the absorption and other operations are conducted, the determination of the volume and the detonation by the electric spark are effected in the tube C (the measuring-tube). The gas is transferred from E into

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(1) Ann. Ch. Pharm. LXX, 281.

(2) From the Bull. d. Naturforsch. Gesellsch. in Moskau XXI, (1848) in J. Pr. Chem. XLVI, 279.

(3) In the translation of the treatise quoted p. 356, contained in the Ann. Ch. Pharm. LXXIII, 129, many important errata in the numbers are corrected.

C by lowering the apparatus (deeper immersion of the bell-jar E in the trough F), and allowing the mercury to escape through A; when gas is to be conducted from C into E, the apparatus is raised, and mercury poured into the limb B. All the determinations of volume are effected in such a manner, that the quantities of gas to be measured in C, may be reduced to the same volume by increasing or diminishing the pressure; the former is effected by pouring mercury into B, the latter by allowing it to escape through A. The pressure upon the gas is measured by the difference of level of the mercury in B and C (which are graduated only longitudinally, not according to capacity); from the amount of this pressure, and the temperature of the gas (for the accurate determination of which B and C are surrounded with water), the volume under normal conditions may be calculated.

In the detonation of mixtures of hydrogen and oxygen by the electric spark, Regnault and Reiset found that, when the hydrogen is in excess, the limit at which the combination of the oxygen is incomplete, and that at which no detonation at all takes place, nearly coincide, and that detonation is still possible when the volume of the oxygen is more than 0.01 of that of the hydrogen, but that it is not so when the former is less than 0.008 of the latter. With an excess of oxygen, the combustion of the hydrogen is complete when its volume is at least 0.12 of that of the oxygen; no combination ensues when the hydrogen is less than 0.065 of the oxygen, and between these limits the combustion is only partial; when the explosive gas is mixed with carbonic acid, the detonation is complete when the volume of the gas is, at least 0.37 of that of the carbonic acid. Nitrogen prevents the complete combustion of the explosive gas in the same degree as an excess of oxygen. In a mixture of atmospheric air and explosive gas the combustion of the latter is complete, when its volume is at least 0.17 of that of the air. Bunsen (*Ann. Ch. Pharm.* LIX, 208) had found, that to ensure complete combustion, the volume of the explosive gas must be at least 0.4 of that of the air, and that when it amounts to more than 0.85, oxidation of the nitrogen, and formation of subnitrate of mercury take place. Regnault and Reiset fixed the latter limit at 0.92, and beyond this point Bunsen's experience is confirmed by their results. These experimenters also found that the diameter of the explosion-tube is not immaterial, for the combustion takes place less easily in narrow tubes than in those of greater diameter. Between pressures of  $\frac{1}{2}$  atmosphere and 2 atmospheres, the influence exerted upon the combustion of the explosive mixture by the pressure to which the gas is subjected is not perceptible. The explosive gas employed in the eudiometrical experiments was prepared by the electrolysis of water, previously boiled, and slightly acidulated with acetic acid; when the gas thus evolved was

Analysis  
of gases.

allowed to escape for several hours, so that the water was retained in a constantly renewed atmosphere of explosive gas, and held in solution the oxygen and hydrogen in the proper proportions, the mixture exploded without leaving any residue; a known volume of atmospheric air underwent no alteration, when mixed with such gas before the explosion(1).

When a mixture of oxygen or atmospheric air, carbonic acid, and excess of hydrogen is exploded, a part of the carbonic acid is always converted into carbonic oxide, for which reason, previously to the determination of oxygen in air containing carbonic acid, the latter must first be removed by potassa; on exploding a mixture of oxygen with an excess of hydrogen, in the presence of carbonic oxide, a quantity of the latter (varying inversely as the excess of hydrogen) is always converted into carbonic acid.

For the estimation of oxygen, Regnault and Reiset prefer the detonation with hydrogen to the employment of deoxidising agents for the absorption of the gas; under all circumstances, however, they recommend attention to the mixing of the gases by their repeated transference to and fro in the various parts of their apparatus. Oxygen is rapidly absorbed by hydrated protoxide of iron suspended in an alkaline liquid, also by an ammoniacal solution of subchloride of copper, or by ammoniacal sulphate of the suboxide; the first of these agents soils the sides of the vessel in which the absorption takes place, the two latter render the residual gas ammoniacal(2). For the absorption of sulphurous acid, Regnault and Reiset employ potassa, oxide of mercury or binoxide of lead (moistened, spread upon a porcelain rod, and dried), the two latter, in order to separate it from carbonic acid, for which purpose, however, a concentrated solution of bichromate of potassa mixed with sulphuric acid is

(1) Doyère (Compt. Rend. XXIX, 600) asserts, that the explosive mixture which is obtained by electrolysis of water always leaves, on explosion, a residue varying from 0.3 to 0.5 per cent, containing hydrogen and nitrogen in the proportion of 2 to 1; but neglects to give any data with regard to the quantity of atmospheric air contained in the water, and the extent to which the result was influenced by the difference in the quantities of hydrogen and oxygen which water is capable of absorbing. The combustion of the explosive gas is complete when mixed with oxygen in the proportion of at least 20 to 100, with nitrogen in that of 30 or 35 to 100, and with hydrogen in the proportion of 45 or 50 to 100. The limit is said to be dependent upon the intensity of the electric spark employed, and upon the pressure to which the gaseous mixture is exposed. If less than 20 volumes of explosive gas be mixed with 100 of air the detonation is incomplete; if more than 45 volumes of explosive gas be mixed with the same quantity of air, oxidation of the nitrogen ensues, and hereupon also, the intensity of the spark and amount of the pressure exert an influence. For the removal of the oxygen by absorption, the ammoniacal solution of subchloride of copper is alone applicable, and even this reagent does not absorb the oxygen completely from a gaseous mixture unless fresh portions of it be repeatedly allowed to act upon the gas.

(2) Both evils are avoided by employing a solution of gallic acid in caustic potassa, by which means, in the Giessen laboratory, the oxygen contained in the air was determined almost as accurately as by the employment of hydrogen.

even more advantageously employed; for the removal of cyanogen they also make use of potassa (moist oxide of mercury acts more slowly); for sulphuretted hydrogen, a solution of sulphate of copper or acetate of lead; olefiant gas is absorbed by pieces of platinum sponge (or of coke) moistened with strong fuming sulphuric acid; (the gaseous mixture must be free from oxygen)(1). Respecting the order in which the operations are conducted, and the calculations in the analysis of particular gaseous mixtures, we refer to the original treatise.

**Carbonic Acid in Mineral Waters.**—Limouzin-Lamothe(2) proposes, for the estimation of carbonic acid in mineral waters, to mix about 10 litres of the waters with an excess of lime-water, and to deduct from the weight of the precipitate produced, that of the insoluble carbonates present in the water. The author of this method seems quite unaware of the fact, that the same process has been in use in Germany for thirteen years, but with this improvement, that in place of lime-water, a mixture of chloride of calcium and ammonia is employed(3).

**Phosphoric Acid.**—II. Rose(4) has published a comprehensive investigation upon the quantitative estimation of phosphoric acid. The description of the process which the author proposes for this purpose, is preceded by a preliminary inquiry, supported by experiments, into the methods now in general use for the separation of phosphoric acid from the bases; the most important results of his paper we subjoin. If the phosphoric acid be precipitated by chloride of ammonium, ammonia and a magnesia-salt, the liquid must not be heated above  $30^{\circ}$ , otherwise a precipitation of hydrate of magnesia will occur; if the carbonate be substituted for pure ammonia, carbonate of magnesia-ammonia easily separates(5). — Phosphate of sesquioxide of iron is decomposed, though with difficulty, by digestion with sulphide of ammonium; the phosphate of magnesia-ammonia, however, precipitated from the filtrate, is contaminated, slightly it is true, with iron, since this metal is not completely separated by sulphide of ammonium. Complete separation is not effected, even by fusing the phosphate of sesquioxide of iron with carbonate of soda

(1) It is well known that several of these methods were long ago employed by Bunsen, whose very complete methods for the analysis of gases Regnault and Reiset appear to have been unacquainted with, or at least, have not mentioned. The literature relating to Bunsen's methods of research will be found collected in the *Ann. Ch. Pharm.* LXXIII, 142.

(2) *J. Chim. Méd.* [3] V, 481.

(3) Liebig and Poggendorff's *Handwörterbuch der Chemie* I. 351.

(4) *Pogg. Ann.* LXXVI, 218; *Berl. Acad. Ber.* 1849, 42 (in abstr.); *J. Pr. Chem.* XLIX, 168; *Ann. Ch. Pharm.* LXXII, 331; *J. Pharm.* [3] XVI, 72; *Instit.* 1849, 229; *Chem. Gaz.* 1849, 177, 199; *Sill. Am. J.* [2] VIII, 181.

(5) According to Weber's analysis, the double salt thus separated may be approximately represented by the formula  $5(\text{MgO}, \text{CO}_2) + 2(\text{NH}_3, \text{CO}_2) + 21 \text{HO}$ .

Phos-  
phoric  
acid.

and sulphur. Berthier's method is not applicable in accurate experiments, since the precipitated basic phosphate of sesquioxide of iron, even when a large excess of sesquioxide of iron is present, yields some phosphoric acid to the ammonia, and cannot be washed without decomposition; this is the case to a still greater extent when the acid present is the pyrophosphoric. If, on the other hand, as proposed by Kobell(1), the sesquioxide of iron be precipitated, together with the phosphoric acid, by digestion in the cold with carbonate of lime, or better, with carbonate of baryta, satisfactory results are obtained; it is only necessary to precipitate the baryta from the solution of the washed and gently ignited precipitate, by sulphuric acid, and to subtract the corresponding weight of carbonate of baryta, and that of the sesquioxide of iron, from the total weight of the precipitate, to obtain that of the phosphoric acid.—Rose has satisfied himself, that from a solution of phosphate of magnesia in hydrochloric acid, the phosphoric acid is entirely precipitated by carbonate of baryta, even without the addition of sesquioxide of iron. The phosphates of baryta, strontia and lime are only partially decomposed by fusion with an alkaline carbonate; in the case of phosphate of magnesia the decomposition is perfect, if the fusion be made with carbonate of potassa and soda (containing equal equivalents); the phosphates of oxide of zinc, oxide of copper, protoxide of manganese, and sesquioxide of iron, are likewise entirely decomposed by fusion with an alkaline carbonate. Instead of Werther's process(2) for the separation of phosphoric acid from sesquioxide of uranium, which consists in fusing the compound at a gentle heat with calcined tartrate of potassa and soda, Rose employs the following, which he considers more simple and less injurious to the platinum crucible. The compound is fused with three parts of carbonate of soda and one part of cyanide of potassium in a platinum crucible, and when the whole is in tranquil fusion, a small stick of cyanide of potassium is added; the crucible is then covered and allowed to cool. The mass is exhausted with hot water, the sesquioxide of uranium filtered off after the addition of some chloride of ammonium, washed with water, dissolved in nitric acid, and the sesquioxide of uranium reprecipitated with ammonia and heated in an atmosphere of hydrogen gas. When a solution of phosphate of sesquioxide of uranium in nitric acid is supersaturated with carbonate of ammonia and mixed with sulphate of magnesia and chloride of ammonium, crystalline carbonate of magnesia-ammonia is precipitated, which renders this method of separating the phosphoric acid inapplicable. Phosphoric acid is separated from chromic acid in the same way as from sesquioxide of uranium, by fusion with carbonate of soda and cyanide of potassium; the residual insoluble sesquioxide of chromium contains alkali, and

(1) J. Pr. Chem. XXXVI, 301.

(2) J. Pr. Chem. XLIII, 321.

must, therefore, be fused with alkaline carbonate and nitrate, and precipitated as chromate of suboxide of mercury.—Sulphuric acid in the presence of alcohol serves only to separate phosphoric acid from lime; the phosphates of the other bases above-mentioned cannot be completely decomposed in this manner, even if sulphate of ammonia be added to diminish the solubility of the sulphate formed.

Phosphoric acid.

The method proposed by H. Rose for the separation of phosphoric acid from the bases, depends upon the solubility of all nitrates and the insolubility of the phosphate of suboxide of mercury in water free from acid. The process enables us to separate the bases from the acid, completely, in one operation, and is inapplicable only in cases where alumina is present; it is conducted as follows. The phosphate, or mixture containing phosphoric acid, is dissolved in just a sufficient quantity of nitric acid, an excess of metallic mercury added, and the solution evaporated to complete dryness in a porcelain capsule placed on a water-bath. If the residue, whilst still warm, has the odour of nitric acid, it is again moistened with water and dried on the water-bath till all excess of acid is expelled. The absence of all free acid, as well as the employment of a temperature for desiccation which does not exceed that of boiling water, are conditions necessary to the success of the experiment. The dry mass is now washed with water, the residue thrown upon as small a filter as possible, and washed with water until the washings leave no fixed residue on platinum. The solution contains the nitrates of the bases which were previously in combination with the phosphoric acid, together with much nitrate of suboxide of mercury. The latter is removed either by addition of hydrochloric acid, and subsequently, without separating the subchloride of mercury, of ammonia, and the bases estimated in the filtrate according to the usual methods; or the solution is evaporated to dryness in a platinum capsule, the mercury-salt expelled by heat, and the residue dissolved in hydrochloric acid.—That portion of the dried mass which is insoluble in water, contains the whole of the phosphoric acid in combination with suboxide of mercury, together with nitrate of suboxide of mercury and metallic mercury. In order to determine the phosphoric acid this residue is well dried, and mixed in a platinum crucible, with an excess of carbonate of potassa and soda; the filter is rolled into a ball and buried in the mixture. The crucible is now moderately heated under a chimney for about half an hour, so that it is not ignited nor its contents fused. In this way the metallic mercury and the mercury-salts with exception of the phosphate, are volatilised. A strong heat is then applied, and the contents of the crucible fused; the fused mass is treated with hot water, in which it entirely dissolves, if the compound under examination contained no iron. The solution is supersaturated with hydrochloric acid, and the phosphoric acid precipitated as phosphate of magnesia-ammonia. If the compound under



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examination contain an oxide of iron, on treating with water the dry mass obtained by evaporating the nitric solution with an excess of metallic mercury, the greater part of the iron remains undissolved as sesquioxide, together with the phosphate of suboxide of mercury, whilst a small portion of it is dissolved out with the nitrates. The residuc is filtered off, washed, and the sesquioxide of iron in solution determined together with the other bases; the residuc, after fusion with carbonate of soda and treatment with water, consists of sesquioxide of iron free from phosphoric acid; it is dissolved in hydrochloric acid and precipitated by ammonia.

In a later treatise(1) H. Rose has described the methods which he employs for the separation of phosphoric acid from bases when alumina is present. — In the ashes of animal and vegetable substances alumina is not detected with certainty, wherefore, for the estimation of phosphoric acid in these substances, the process just described can be made use of; it is otherwise, however, with rocks such as basalt, which contain compounds of phosphoric acid (apatite) diffused throughout their mass, and from which the phosphoric acid is dissolved out, together with alumina and other bases, on treatment with acids. If the nitric solution of such a mineral be evaporated to dryness with an excess of mercury, and the residue treated with water, the greater part of the alumina is dissolved out together with some phosphoric acid. He, therefore, substitutes the following process. The solution of the compound in an acid (hydrochloric acid is best for this purpose) is diluted with water, digested for several days in the cold with carbonate of baryta, filtered, and the undissolved residue washed with cold water. (When lime is present the precipitate must be washed until the washings, after precipitation of the baryta with sulphuric acid and supersaturation of the filtrate with ammonia, give no farther precipitate with oxalic acid). The filtrate contains the bases which were in combination with phosphoric acid, with the exception of alumina, sesquioxide of iron, and other weak bases which are completely precipitated together with the phosphoric acid. From the solution the baryta is first precipitated with sulphuric acid, and the bases then estimated according to the usual methods. (If the compound has been originally dissolved in nitric acid, the sulphate of baryta is very difficult to wash if lime be present; some hydrochloric acid must then be added to the washing-water, and the excess of acid expelled from the filtrate by evaporation, previously to the saturation with ammonia; when treated with water there will then remain behind a small quantity of sulphate of baryta which had been dissolved by the acid washing-water). The undissolved portion which contains, together with an excess of carbonate of

(1) Pogg. Ann. LXXVIII, 217; Berl. Acad. Ber. 1849, 220 (in abstr.): J. Pr. Chem. XLVIII, 252; Instit. 1849, 389.

baryta, all the phosphoric acid, alumina and sesquioxide of iron, is dissolved in as small a quantity as possible of dilute hydrochloric acid, the baryta is precipitated with sulphuric acid, avoiding a great excess of the latter, and the filtrate previously to evaporation is saturated with carbonate of soda. The liquid is now evaporated to dryness together with the separated phosphate of sesquioxide of iron and phosphate of alumina, and the dry residue is ignited, intimately mixed with an equal weight of pure silica and six parts of carbonate of potassa, and heated in a large platinum crucible, first moderately, then to bright redness. The ignited mass is exhausted with water, the silica is precipitated with carbonate of ammonia, and the precipitate, after complete subsidence, filtered off and washed with cold water containing a little carbonate of ammonia. The filtrate is supersaturated, first with hydrochloric acid, then with ammonia, and the phosphoric acid is precipitated from the solution as phosphate of magnesia-ammonia. The undissolved portion is digested with hydrochloric acid, evaporated to dryness, and the silica separated as usual from the sesquioxide of iron and alumina.

A. Müller(1) estimates the phosphoric acid in solutions containing alkaline earths, by adding a known quantity of sesquioxide of iron in the form of a graduated solution of the sesquichloride, the liquid being then supersaturated, first with ammonia, then with acetic acid, and heated to ebullition, when all the sesquioxide of iron and the phosphoric acid are precipitated. The weight of the latter is obtained by deducting from the total amount of the ignited precipitate that of the sesquioxide of iron added. If the solution originally contained sesquioxide of iron, its quantity must obviously be ascertained and taken into the calculation. This method is inapplicable when alumina is present together with sesquioxide of iron, since the former is likewise, but only partially, precipitated on boiling, from the acetic solution.—Th. Way and G. H. Ogston(2) have followed this method in the examination of a great number of ashes which they have analysed. (See "Agricultural Chemistry"). They found(3) that the phosphate of sesquioxide of iron which is precipitated on adding acetate of ammonia to an acid solution, containing a salt of sesquioxide of iron and excess of an alkaline phosphate (either at the ordinary temperature or at the boiling-point), always varies in composition according to the relative quantities of the reagents employed, an important observation, since it discloses a source of error which prevents the employment of Raewsky's method for the estimation of phosphoric acid(4). Way and Ogston ultimately arrived at the

(1) J. Pr. Chem. XLVII, 341.

(2) Journ. of the Royal Agricult. Society of England, VIII, Part 1.

(3) Journ. of the Royal Agricult. Soc. of England, IX, Part 1.

(4) Annual Report for 1847 and 1848, II, 213.

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following modification of the process for estimating phosphoric acid in ashes, which deserves the preference over the preceding process, since its accuracy is not dependent upon errors in the determination of the amount of sesquioxide of iron added. The hydrochloric solution of the ash is decomposed with acetate of ammonia, as usual for the separation of the phosphate of sesquioxide of iron; from the filtrate now containing free acetic acid the lime is precipitated by oxalate of ammonia. The solution is filtered from the oxalate of lime and divided into two parts; in one the magnesia is precipitated by ammonia, and if necessary by phosphate of soda; in the other portion the phosphoric acid is determined by means of sulphate of magnesia, chloride of ammonium and ammonia.

E. Cottereau(1) has described a method of estimating phosphoric acid, which shows that its author is but little acquainted with the behaviour of the phosphates. It depends upon the erroneous supposition that insoluble phosphates are decomposed by boiling with a solution of alkaline carbonate. The phosphoric acid thus brought into solution is to be precipitated, after neutralisation with nitric acid, by means of a solution of nitrate of silver of known strength. The precipitate is said to be  $2\text{AgO}, \text{PO}_5$ .—Another process, proposed by Leconte(2), is founded upon the insolubility of phosphate of sesquioxide of uranium. The phosphoric acid is precipitated from the diluted aqueous, or slightly acid solution, at the boiling-point, by means of a standard solution of nitrate of sesquioxide of uranium.—E. Moride and A. Robierre(3) are of opinion that the phosphoric acid contained in manures, animal charcoal, &c., can be estimated with sufficient accuracy by the employment of a standard solution of acetate of lead.

Wackenroder(4), in a new series of experiments upon the estimation of phosphoric acid in the form of phosphate of baryta, in solutions containing carbonates and phosphates, together with chlorides, has shown that chloride of barium will throw down the whole of the phosphoric acid. The baryta-precipitate is treated with very dilute nitric acid, when sulphate of baryta (which must be treated with hydrochloric acid before being weighed) remains behind. From the solution, by addition of ammonia, all the phosphoric acid may be precipitated as phosphate of baryta, which after ignition has the formula  $5\text{BaO}, 2\text{PO}_5$  (containing 27.16 per cent. of  $\text{PO}_5$ ). The hydrochloric solution, on the other hand, as Ludwig(5) has pointed

(1) Compt. Rend. XXVIII, 128; Instit. 1849, 26; Chem. Gaz. 1849, 145.

(2) Compt. Rend. XXIX, 55; Instit. 1849, 226; J. Chim. Méd. [3] V, 619; J. Pr. Chem. XLIX, 380.

(3) Chem. Gaz. 1849, 280.

(4) Arch. Pharm. [2] LVII, 17.

(5) Annual Report for 1847 and 1848, II, 214.

out, yields with ammonia a precipitate which contains chloride of barium.

Phosphoric acid.

R. Wagner(1) has collected the researches which appeared in 1847 and 1848 upon the estimation of phosphoric acid, and the separation of magnesia and alkalis.

**Removal of Sulphuretted Hydrogen from Solutions.**—For the removal of sulphuretted hydrogen from acid solutions, in which the chlorine is to be precipitated by nitrate of silver, it is advantageous, according to H. Rose(2), to add a solution of sulphate of sesquioxide of iron, by which means sulphur only is separated, and may be filtered off. When salts of oxide of copper, and other heavy metallic oxides are employed, a combination of the metallic sulphide and chloride, similar to that which Rose has pointed out in the case of salts of mercury, is easily formed.

**Analysis of Chlorinated Organic Compounds.**—Städeler(3) has satisfied himself by a direct experiment, that on passing oxygen-gas over a heated mixture of oxide and chloride of copper, chlorine is evolved, which, as has been long known(4), may introduce an error into the determinations of carbon and hydrogen in chlorinated organic substances. Accurate results are however obtained, if a spiral of thin sheet-copper be laid in the fore part of the combustion-tube, and there maintained at a red-heat during the combustion, the current of oxygen being interrupted when a layer of oxide appears on the hinder part of the copper spiral.—A. Völeker(5) proposes that the oxide of copper employed in the combustion be mixed with  $\frac{1}{3}$  of binoxide of lead, by which all the chlorine is completely retained, even during protracted exposure to oxygen gas, which cannot easily be avoided when chlorate of potassa is placed at the closed end of the combustion-tube. Such a mixture of chloride of copper with oxides of copper and lead, did not evolve a trace of chlorine when ignited in a stream of oxygen.

**Bromine. Iodine.**—A. Reynoso(6) has proposed, for the recognition of iodine and bromine, the employment of binoxide of hydrogen, which is preferable to chlorine, since an excess does not destroy the reaction, thus rendering the test more certain. It succeeds also in cases where the iodine can no longer be detected by chlorine. In order to test for iodine some binoxide of barium is introduced into a test-tube, then water, hydrochloric acid and starch-paste, and lastly, when bubbles of gas are evolved, the substance to be tested; even

(1) J. Pr. Chem. XLVI, 414.

(2) Pogg. Ann. LXXVIII, 405.

(3) Ann. Ch. Pharm. LXIX, 334.

(4) Liebig and Poggendorff's Handwörterb. d. Chem. I, 373.

(5) Chem. Gaz. 1849, 245.

(6) Ann. Ch. Phys. [3] XXVI, 285; Compt. Rend. XXVIII, 562; J. Pharm. [3] XV, 406; Instit. 1849, 137; J. Pr. Chem. XLVII, 467; Ann. Ch. Pharm. LXXXII, 328.

Bromine.  
Iodine.

with  $\frac{1}{1000000}$  of an iodine-compound a violet or dark-blue tint is immediately produced. Since, in this case, an excess of binoxide of hydrogen is always present, the presence of metallic sulphides, of hyposulphites and sulphites, does not influence the reaction; in the case of an abundant precipitation of sulphate of baryta the mixture must be shaken, in order that the surface of the binoxide of barium may not be protected from the acid. For the detection of bromine the same process may be employed (fiery-red bromide of starch being obtained), or instead of starch-paste, the solution may be agitated with ether, which dissolves the bromine, with a more or less intense yellow colour. If ether containing bromine be agitated with starch the latter is coloured, which prevents the simultaneous testing for iodine and bromine by means of ether and starch-paste.

**Iodine.**—Casaseca(1) considers the employment of pure nitric acid, with some starch, for the detection of iodine, as certain as that of binoxide of barium.

A. Vogel, jun.(2) finds that the production of the iodine-reaction with starch-paste, by means of nitric acid, is only certain when the latter contains a trace of sulphuric, hydrochloric, or nitrous acid; whence the paste of iodide of potassium and starch may be used as a test of the purity of the (previously diluted) nitric acid.

Thorel(3) boils the solution to be tested for iodine, or the solid substance diffused through water, with a few drops of nitric and hydrochloric acids, a paper moistened with starch-paste being placed in the neck of the flask; if much organic matter be present, the coloration of the starch-paste does not appear until some tartrate of potassa is added.

A communication by Dorvault(4) upon the estimation of iodine contains no new statements.

**Fluorine.**—H. Rose(5) has shown that in the precipitation of fluorine from acid solutions in the form of fluoride of calcium, it is preferable to neutralise the solution with carbonate of soda rather than with ammonia, on account of the solubility of fluoride of calcium in ammoniacal salts. The precipitate containing fluoride of calcium and carbonate of lime is ignited, supersaturated with acetic acid, evaporated to dryness in a water-bath and exhausted with water, when fluoride of calcium remains undissolved. In many cases the fluorine may also be completely precipitated from neutral solutions in the form of fluoride of barium, or fluoride of lead, by addition of the corresponding nitrates in the presence of alcohol, the precipitate

(1) Instit. 1849, 385.

(2) Repert. Pharm. [3] III, 361.

(3) J. Pharm. [3] XVI, 291; J. Chim. Méd. [3] V, 486.

(4) Instit. 1849, 17.

(5) Pogg. Ann. LXXIX, 112; Berl. Acad. Ber. 1849, 357; J. Pr. Chem. XLIX, 309; Ann. Ch. Pharm. LXXII, 343; Instit. 1850, 134.

being afterwards washed with spirit of wine; the fluoride of barium is ignited, that of lead merely dried at  $100^{\circ}$ . If the solution contains metallic chlorides, the precipitates are not free from the chlorides of barium and lead.—Fluoride of calcium and several other insoluble fluorides are completely decomposed by fusion with an alkaline carbonate only when silica is present, so that an alkaline silicofluoride is at first produced, and afterwards decomposed by the excess of alkaline carbonate. The fused mass is treated with water, the silica precipitated with carbonate of ammonia, and from the filtrate, the fluorine, by addition of a lime-salt. Combinations of fluorides with insoluble phosphates are not decomposed by fusion with an alkaline carbonate and silica, if we except the compounds of phosphate of alumina with fluorides. To separate phosphoric acid from fluorine in the aqueous alkaline solution (freed from silica by carbonate of ammonia), we may either precipitate the former with an excess of basic nitrate of suboxide of mercury (in which the subfluoride of mercury at first precipitated is soluble), and treat the precipitate with carbonate of soda, as described under phosphoric acid (page 396), or the alkaline solution containing phosphoric acid and fluorine may be precipitated by a lime-salt, the weight of the phosphate of lime and fluoride of calcium estimated, after removing the carbonate of lime in the manner previously described, and digested in a platinum-crucible with concentrated sulphuric acid till the fluorine is completely expelled; the phosphoric acid and excess of sulphuric acid are removed by alcohol, the weight of the undissolved sulphate of lime is determined, and the phosphoric acid precipitated (after evaporation of the alcohol), as phosphate of magnesia-ammonia. From the difference between the weight of the original precipitate, and the joint weights of the phosphoric acid and lime, the weight of the fluorine which was substituted for the equivalent of oxygen in the lime is calculated. A mixture of sulphate of baryta with fluoride of calcium, as it sometimes occurs in nature, is not completely decomposed by hydrochloric acid; the decomposition succeeds better with alkaline carbonate and silica at a red-heat. The fused mass is treated with water, the silica removed from the alkaline solution with carbonate of ammonia, the solution supersaturated with hydrochloric acid and mixed with chloride of barium, which precipitates sulphate of baryta (free from fluoride of barium).

**Nitrogen.**—In the estimation of nitrogen in compounds rich in carbon by the method of Dumas, Mulder(1) observed the formation of carbonic oxide, even in an analysis in other respects well conducted. This gas is produced by the decomposition of the carbonic acid evolved from the bicarbonate of soda in its passage over the unconsumed red-hot carbon, and is carried along by the

(1) Scheik. Onderz. V, 4. Stuk, 277.

Nitrogen.

rapid stream of gas before it can be reconverted into carbonic acid by the oxide of copper. On this account, it is advisable, in the analysis of compounds rich in carbon, to mix them very carefully with the oxide of copper, and to evolve the carbonic acid from the bicarbonate of soda very slowly, especially towards the end of the process. A plug of copper-turnings, oxidised on the surface by ignition in air, and retained at a red-heat throughout the combustion, might likewise entirely prevent the passage of carbonic oxide into the gas-cylinder.

Th. Bromeis(1) has described a method, communicated to him by Bunsen, for the analysis of the nitrite and hyponitrite of lead, which is applicable to all the salts of metallic oxides with nitrogen-acids, capable of being decomposed by heat, and allows of the determination of all the constituents by one experiment. It consists in decomposing the compound in an atmosphere of nitrogen, passing the evolved gases over ignited metallic copper, and abstracting the water by means of chloride of calcium. The apparatus consists of a chloride of calcium tube 2 feet in length, connected with another tube (A) about 20 inches long, filled with reduced copper-turnings, which serve to abstract the oxygen from the air; this tube is drawn out to a point at its other extremity, where it is connected with another tube (B) of 10 inches long, likewise drawn out, and containing reduced copper in its anterior portion; in the hinder part of this tube is placed a platinum boat, filled with the substance to be analysed. This last tube is weighed with its contents, and the weight of the substance and of the little platinum boat are likewise known. Connected with this tube is a chloride of calcium tube, and with this again a wider glass tube (C), which contains reduced copper to prevent an introduction of oxygen (by diffusion) from the aspirator, which is connected with this part of the apparatus. After the copper for the two little tubes B and C has been dried in the water-bath, and the outer tube C filled with it, and connected with the aspirator, the little platinum boat with its contents is first introduced, then the copper into the middle tube B, the chloride of calcium tube and the tube B weighed, connected together, and the latter surrounded with copper-foil, to prevent the fusion of the ashes upon it, and placed in a charcoal fire. The tube A is heated to redness, and when all hygroscopic moisture is expelled from it, it is connected with the tube B, and the aspirator is put in operation till all the atmospheric air is replaced by nitrogen. The tube C is now heated to redness, and B fused with the blow-pipe, at the narrow part between the caoutchouc and the copper-foil; the last-mentioned tube is gradually heated to redness, commencing at the end nearest to the aspirator. After the experiment is concluded, and the tube cooled, the apparatus is dis-

(1) Loc. cit. at page 188 of the present work.

connected where the chloride of calcium tube joins the outer tube C, the closed point broken off, air drawn through the apparatus, and the chloride of calcium tube and the tube B are weighed, together with the points which were broken and fused off. The diminution of weight of the tube B, is the joint amount of nitrogen and water in the substance; the weight of the water (and therefore that of the nitrogen) is obtained from the increase of weight of the chloride of calcium tube. Lastly, if the weight of the oxide of lead remaining in the little platinum boat is determined, and this weight, together with that of the water and nitrogen, deducted from the weight of the substance employed, the amount of oxygen present is ascertained.

In the analysis of the combinations of nitric acid with suboxide of mercury, Marignac(1) estimated the nitrogen by the method used in the analysis of an organic substance. The salt to be analysed was placed at the end of a combustion-tube, which was filled up with spongy metallic copper, and connected with an U-shaped tube, containing pumice-stone moistened with oil of vitriol; from this a bent tube conducted the gas into a graduated gas-jar, which could be raised or depressed at pleasure in a cylinder of mercury. After the experiment the increase in volume of the air in the jar, and the increase of weight of the desiccating tube were estimated, and the amounts of nitrogen and water ascertained. Marignac has satisfied himself that the sources of error in this process are quite unimportant. If so much of the mercury-salt be employed that from 80 to 120 c. c. of nitrogen are obtained, and a narrow tube be made use of, the error consequent on the absorption of oxygen is scarcely perceptible; the first effect of heat upon the salt is the expulsion of water, then dry nitrogen passes over, and carries all the water with it into the desiccating tube; lastly, the mercury-vapour is evolved, and is so completely condensed between the metallic copper and the cork, that the determination of the water is not affected by it.

**Nitrous Acid.**—It is well known that when nitrous acid comes in contact with urea, both substances are decomposed, yielding carbonic acid, nitrogen and water; the determination of urea by Millon's process(2) depends upon this reaction. Schwarz(3) makes use of this process, conversely, for the estimation of nitrous acid. The compound of nitrous acid is brought in contact with an excess of urea, and then with sulphuric acid, in an apparatus fitted for the estimation of the carbonic acid. 1·000 part by weight of carbonic acid evolved, represents 0·760 of nitrous acid.

**Cyanogen.**—Ch. Heisch(4) determines the cyanogen in cyanide of mercury in the form of cyanide of silver, to effect which he brings

(1) Loc. cit. p. 193 of the present volume.

(2) Annual Report for 1847 and 1848, Vol. II, 249.

(3) Ann. Ch. Pharm. LXX, 56.

(4) Chem. Soc. Qu. J. II, 219.



**Cyanogen.** the compound in contact with zinc, water and sulphuric acid, in an apparatus for evolving gas, from which the hydrocyanic acid produced is conducted into nitrate of silver; the precipitate is collected and weighed. In order that the zinc may not be protected by amalgamation from the action of the acid, a little nitric acid is added to the mixture. The author considers this method applicable to the analysis of the double cyanides; a determination made with cyanide of mercury gave a satisfactory result.

**Metals in General.**—C. F. Plattner(1) has described, in a little treatise, the methods invented by himself, and employed in the assay-laboratory of the Freiberg smelting-works, for the quantitative estimation of cobalt, nickel, copper, lead and bismuth, in the dry way. The process for the determination of these metals in ores and furnace-products mainly consists in the conversion of the copper, nickel, cobalt and the greater part of the iron into arsenides, with simultaneous separation of the lead and bismuth in the metallic state, and in the subsequent roasting of the arsenides formed; in this process, first the arsenide of iron, and after the volatilisation of the excess of arsenic which is still present, the arsenide of cobalt and then the arsenide of nickel, are separated from the arsenide of copper by smelting, and from the amount of the arsenides of cobalt and nickel ( $\text{Co}_4\text{As}$  and  $\text{Ni}_4\text{As}$ ), which are constant at higher temperatures, the amount of pure cobalt and nickel is obtained by calculation; lastly, the arsenic combined with the copper is volatilised, when the copper alone remains behind. For the details of the process we must refer to the original treatise of the inventor, whose merits in this department of analytical chemistry are universally acknowledged.

For the analysis of the salts of those metallic oxides which are insoluble in potassa, Roucher(2) proposes to precipitate the bases by a known volume of an alkaline solution graduated by means of sulphuric acid, to wash thoroughly, and then to estimate the amount of alkali in the filtrate by means of a graduated acid. The difference in the amount of alkali corresponds to the amount of acid which was contained in the salt.

**Separation of Nitrates from Chlorides.**—Freshly precipitated phosphate of silver is decomposed, when digested and subsequently evaporated to dryness with chloride of magnesium, chloride of calcium, or chloride of sodium, into phosphate of magnesia, lime, or soda, insoluble in water or alcohol, and chloride of silver; nitrate of magnesia and nitrate of lime do not decompose it. This reaction has induced Lassaigne(3) to recommend phosphate of silver for the separation of nitrate of magnesia from chloride of magnesium, or of nitrate of lime

(1) Beitrag zur Erweiterung der Probirkunst. Freiberg, 1849.

(2) Compt. Rend. XXIX, 283.

(3) J. Pharm. [3] XVI, 289; Compt. Rend. XXIX, 183; Instit. 1849, 259.

from chloride of calcium, which are frequently met with in well-waters. The phosphate of silver is stated to be very sparingly soluble in solutions of the nitrates. By this reagent also, chloride of sodium may be easily separated from certain organic substances (*e. g.* sugar), since the phosphate of soda thus produced is insoluble in alcohol.

Separation of nitrates from chlorides.

**Behaviour of Baryta and Strontia before the Blow-pipe.**—According to J. S. Muspratt(1) chloride of barium, nitrate, and especially acetate of baryta, tinge the blow-pipe flame of a bright-green, whilst caustic-baryta imparts a yellowish colour; of strontia-salts, those only which are soluble in water colour the flame carmine-red; in many cases it is necessary that they be first moistened with water: chloride of barium and chloride of calcium do not interfere with the strontia-reaction, but soda-salts completely prevent it. A mixture of a strontia-salt with a salt of potassa colours the outer flame indistinctly carmine-red, whilst the violet colour appears around the test-specimen.

**Lime.**—A. Reynoso(2) has made an observation which is of some importance for the estimation of lime, that the oxalate of this base, digested in soluble salts of copper (chloride, sulphate and nitrate), is gradually converted into oxalate of copper, with formation of a soluble lime-salt(3). In the presence of much chloride of sodium, chloride of calcium, or chloride of ammonium, oxalate of lime dissolves in chloride of copper; on agitation, or long standing, oxalate of copper separates; on boiling oxalate of lime with the soluble salts of oxide of silver, oxide of lead, oxide of cadmium, oxide of zinc, oxide of nickel, oxide of cobalt, strontia and baryta, a soluble lime-salt is formed, and the oxalates of these bases are precipitated.

**Separation of Magnesia from Alkalies.**—For the estimation of the magnesia (or of the oxides of zinc, nickel and cobalt) and alkalies in the same solution, H. Watts(4) has proposed to precipitate the first by a known weight of carbonate of soda at a boiling heat, to neutralise the filtrate with sulphuric acid, or if the bases were dissolved in hydrochloric acid, with the latter, to evaporate to dryness, ignite and weigh. After deducting the amount of sulphate of soda, or chloride of sodium, which corresponds to the carbonate of soda employed, the amount of the potassa- or soda-salt present is ascertained. This method does not possess any decided superiority over the employment of phosphate of ammonia(5), as proposed by Heintz and Erdmann,

(1) Ann. Ch. Pharm. LXXII, 118; Laur. and Gerh. C. R. 1850, 161.

(2) Compt. Rend. XXIX, 527; J. Pr. Chem. XLIX, 511.

(3) Reynoso's statement with regard to the conversion of oxalate of lime into oxalate of copper, by means of chloride of copper, is strictly correct. Malate and citrate of lime are perfectly soluble in chloride of copper in the cold, and by this solubility are easily distinguished and separated from oxalate and tartrate of lime.

(4) Chem. Soc. Qu. J. II, 99. (5) Annual Report for 1847 and 1848, Vol. II, 226.

Chromium.

but is attended with the great disadvantage, that the accuracy of the estimation is impaired in proportion as the quantity of the alkalis diminishes.

**Chromium.**—Chromic acid, in acid solutions, is converted into sesquioxide of chromium by salts of protoxide of iron ( $6 \text{FeO} + 2 \text{CrO}_3 = 3 \text{Fe}_2\text{O}_3 + \text{Cr}_2\text{O}_3$ , according to which 1.000 of metallic iron represent 0.600 of  $\text{CrO}_3$ , or 0.4571 of  $\text{Cr}_2\text{O}_3$ , or 0.3143 of Cr). If a solution of protoxide of iron of known strength be added in excess to the acidified solution of the chromium-compound, in which all the chromium has been previously converted into chromic acid, and if the amount of protoxide of iron still remaining be determined according to Marguerite's method, by means of a graduated solution of permanganate of potassa (an operation in every respect similar to the estimation of nitre by Pelouze's(1) method), then the difference between the amount of iron still present as protoxide, and the whole quantity employed, represents the amount converted into sesquioxide by the chromic acid, and from this the amount of the latter may be calculated. Upon this principle a method described by H. Schwarz(2) for the estimation of chromium is based. To determine the amount of this metal in chrome-iron ore, a weighed portion of the finely divided mineral to be analysed is added to fused hydrate of potassa heated to redness in a silver crucible; sticks of fused chlorate of potassa are then introduced till the mass is clear, and of a transparent yellow colour; upon cooling it is dissolved in hot water, the solution supersaturated with sulphuric acid, and the chromic acid determined as described above. If the chromium-compound is fused with nitre the aqueous solution contains nitrous acid: this may be decomposed by boiling the alkaline liquid with chloride of ammonium.

**Uranium.**—A. Patera(3) proposes the following process for the determination of the amount of uranium present in uranium-ores: the nitric solution is precipitated with excess of carbonate of potassa, the filtrate evaporated, and the ignited residue extracted with water, which leaves undissolved a combination of potassa and sesquioxide of uranium, from which the amount of uranium present is to be calculated. Since some sesquioxide of uranium is precipitated together with the sesquioxide of iron, and cannot be redissolved by an excess of carbonate of potassa, and other oxides remain dissolved in the bicarbonate of potassa together with sesquioxide of uranium, this method of determining the uranium cannot furnish very accurate results.

(1) Annual Report for 1847 and 1848, Vol. II, 223.

(2) Ann. Ch. Pharm. LXIX, 209; J. Pr. Chem. XLVII, 15; Chem. Gaz. 1849, 143.

(3) From Berichte der Freunde der Naturwissensch. in Wien, IV, in J. Pr. Chem. XLVI, 182.

**Arsenic.**—The best form for the estimation of arsenic, according to H. Rose(1), is the arseniate of magnesia and ammonia, as originally proposed by Levöl; the precipitate must not, however, be ignited as Levöl recommends, since a loss of arsenic then results from its reduction to the metallic state. The precipitate is best dried *in vacuo* over sulphuric acid (and is then expressed by  $2 \text{MgO}$ ,  $\text{NH}_4\text{O}$ ,  $\text{AsO}_5 + 12 \text{HO}$ ), or at  $100^\circ$  (when its formula is  $2 \text{MgO}$ ,  $\text{NH}_4\text{O}$ ,  $\text{AsO}_5 + \text{HO}$ ). The conversion of an arsenic-compound, even of sulphide of arsenic, into arsenic acid, is most easily effected by the action of chlorate of potassa and nitric acid at a gentle heat. Arsenious acid is most accurately estimated by the amount of gold reduced from the chloride (2 eqivs. of gold represent 3 eqivs. of arsenious acid). All arseniates, even arseniate of lime, are completely decomposed by fusion with alkaline carbonate; the arsenic acid may also be separated by treatment with metallic mercury and nitric acid (as stated in the case of phosphoric acid, page 395), but this method cannot be well made use of, since the platinum crucible is very powerfully attacked by this process, and if a porcelain crucible be employed silica is found in solution.

P. Kotschoubey(2) has communicated a method of determining arsenic, which is founded upon the same principles as that employed by Raewsky(3) for the estimation of phosphoric acid, and is therefore open to the same doubts with respect to accuracy. The solution, which must contain the arsenic in the form of arsenic acid, is precipitated by acetate of sesquioxide of iron (or a mixture of solutions of iron-alum and acetate of soda) in the presence of free acetic acid; the precipitate of arseniate of sesquioxide of iron (which, dried at  $100^\circ$  is said to possess constantly the formula  $\text{Fe}_2\text{O}_3$ ,  $\text{AsO}_5 + 5 \text{HO}$ ) is dissolved in hydrochloric acid, the solution reduced by metallic zinc, and the protoxide of iron in the filtrate determined, according to Marguerite's method, by means of a graduated solution of permanganate of potassa. From the quantity of iron present, that of the arsenic acid is calculated according to the above formula.

Kobell(4) reduces the arsenic acid contained in the liquid to the state of arsenious acid, by passing through it sulphurous acid, whilst the air is excluded; chloride of barium is then added, the solution rapidly heated to ebullition (to expel excess of sulphurous acid), and the amount of arsenic acid calculated from the weight of the sulphate of baryta. Sulphide of arsenic is oxidised by *aqua-regia*, the solution evaporated with the addition of a little sulphuric acid to expel all the nitric acid, then mixed with hydrochloric acid, precipitated

(1) Pogg. Ann. LXXVI, 534; Berl. Acad. Ber. 1849, 124; J. Pr. Chem. XLIX, 166; Ann. Ch. Pharm. LXXII, 336; Instit. 1849, 308.

(2) Petersb. Acad. Bull. VIII, 129; J. Pr. Chem. XLIX, 182.

(3) Annual Report for 1847 and 1848, Vol. II, 213.

(4) J. Pr. Chem. XLVI, 491.

Arsenic.  
its detec-  
tion in  
judicial  
cases.

with chloride of barium, and the filtrate being free from sulphuric acid is treated as above.

**Detection of Arsenic in Judicial Cases.** — Wöhler(1) prefers the employment of chlorine gas for the destruction of the organic matter and extraction of arsenic in medico-legal investigations; the chlorine may either be allowed to act directly upon the organic matter, or the latter may be dissolved in as small a quantity as possible of potassa-solution, the liquid acidified and treated with chlorine. After the removal of the excess of chlorine by digestion at a gentle heat, the liquid is filtered, heated to about  $70^{\circ}$ , and saturated with washed sulphuretted hydrogen gas, by which means the arsenic acid is precipitated as rapidly as when it is previously reduced to arsenious acid by treatment with sulphurous acid, a reduction which can only be slowly effected. If the gas be passed through the cold solution, it must, when completely saturated, be allowed to stand for twenty-four hours in a closed vessel. By gently heating in an open vessel, the excess of gas is then expelled, the solution decanted, the precipitate collected upon a small filter, thoroughly washed, and the filtrate once more saturated with sulphuretted hydrogen, in order to ascertain that all arsenic is separated. The removal of the organic matter which is precipitated together with the sulphide of arsenic, is effected, according to Wöhler, with ease and certainty in the following manner. The filter, together with the precipitate, is digested in a sufficiently large crucible of genuine porcelain, with concentrated nitric acid, until it is decomposed and reduced to a homogeneous mass; the free nitric acid which it contains is saturated by pure carbonate of soda, gradually added, and the mass is carefully dried. It is important that it should contain the requisite excess of nitrate of soda, which is easily insured by adding a sufficient quantity of nitric acid at the commencement. The crucible is now heated over a large spirit-lamp to the fusing-point of the nitrate of soda, when the mass first becomes brown, then blackens, and fuses, without explosion or deflagration, into a colourless liquid. The saline mass when cold, after gradual addition of pure concentrated sulphuric acid, is heated in the crucible until all nitric and nitrous acids are completely expelled. The nitric acid, as well as the carbonate of soda employed, must be free from chlorine, in order that, during this treatment with sulphuric acid, no chloride of arsenic may be volatilised. If the sulphuretted hydrogen precipitate contain antimony, this will be found in the fused mass as antimoniate of soda, and on extraction with water will remain undissolved as a white powder, which must be filtered off before the treatment with sulphuric acid. If sulphide of copper be present, black oxide of copper will then also remain behind. The acid saline mass (containing no nitric

(1) Ann. Ch. Pharm. LXIX, 364; J. Pharm. [3] XVI, 395.

acid) is afterwards dissolved in the crucible with the least possible quantity of hot water, and the solution gradually introduced by a funnel tube into Marsh's apparatus previously filled with hydrogen gas(1). If a ring of metallic antimony is obtained, independently of the well-known methods, it is easily distinguished from an arsenic ring by being heated afresh in hydrogen gas, when it is much less easily volatilised, does not impart the least garlic odour to the evolved gas, and allows a number of fused globules to be distinctly perceived in the tube with the aid of a lens. The chief difficulty, as Wöhler very justly remarks, in this process, is in avoiding the introduction of arsenic from impure reagents and apparatus; on this account all the substances to be employed, even the chlorate of potassa and the filter-paper, should previously be carefully tested.

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Boissenot(2) evolves the chlorine for the decomposition of organic matter in the examination for arsenic, from a paste of chloride of lime, to which he adds, drop by drop, commercial hydrochloric acid. He supposes, that even hydrochloric acid containing arsenic can be employed for this purpose without fear that this metal will pass over with the chlorine, since the evolution proceeds regularly in the cold, and the lime which is present fixes the arsenic acid. Notwithstanding this statement of Boissenot, which is unsupported by any direct experiment, it is advisable in every case to use hydrochloric acid which has been tested and found free from arsenic.

**Distinction of Arsenic and Antimony.**—J. H. Van den Broek(3) has found, on repeating the experiments of Schönbein(4) upon the disappearance of antimony and arsenic spots in an atmosphere of ozone, obtained by the evaporation of phosphorus, that this furnishes no satisfactory means of distinguishing between these two metals, since the periods required for the disappearance of arsenic and antimony-spots of equal thickness are not very different. Contrary to the statement of Schönbein, he observed that the disappearance of the arsenic-spot requires a longer time than is necessary with an antimony-spot, and that in both cases the places previously occupied by the spots exhibit an acid reaction.

In order to distinguish and separate antimonietted from arsenietted hydrogen, Schenkel and Rieckher(5) have taken advantage of the observation made by Meissner and Hankel(6), that the former gas is decomposed by an alcoholic solution of

(1) In order to obtain the arsenic in an appropriate form for Marsh's test, the solution of sulphide of arsenic in potassa may be conveniently de-sulphurised by means of teroxide of bismuth. The filtrate, when acidified, may be poured into the apparatus.

(2) J. Pharm. [3] XV, 185.

(3) Scheik. Onderz. V, 3. Stuk, 225.

(4) Annual Report for 1847 and 1848, 231.

(5) Jahrb. Pr. Pharm. XIX, 257.

(6) J. Pr. Chem. XXV, 243; L. Gmelin's Handbuch der Chemie, 4. Aufl., II, 758.

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potassa. The antimonietted hydrogen, in their experiments, was so completely decomposed by slowly passing through a solution of 1 part of caustic potassa in 3 parts of alcohol, that the hydrogen flame no longer furnished a spot, whilst it at once indicated an admixture of arsenietted hydrogen.

**Separation of Arsenic from Antimony.**—If antimony and arsenic exist in a hydrochloric solution, Ullgren(1) directs that it be treated with an alkaline hypochlorite to convert the arsenic into arsenic acid, that tartaric acid be then added in great excess, afterwards ammonia and sulphate of magnesia, when the arseniate of magnesia-ammonia will be precipitated; this precipitate is washed with dilute ammonia, dissolved in nitric acid, the solution evaporated to dryness in a platinum crucible, the residue mixed into a paste with a weighed quantity of calcined magnesia and some water, dried and ignited. After deducting the amount of magnesia added, the arsenic acid is calculated from the difference, according to the formula  $2 \text{MgO}, \text{AsO}_5$ , (containing in 100 parts, 73.593 of arsenic acid, or 48.018 of arsenic.)—See also page 407.

**Antimony.**—H. Rose(2) has pointed out that when antimony is present in a hydrochloric solution in the form of teroxide,  $\text{SbO}_3$ , it can be estimated in the same manner as arsenious acid by means of an excess of terchloride of gold. If, together with the metallic gold, antimonious acid also separates, which can be prevented by a large excess of hydrochloric acid, it may be removed by fusing the precipitate together with the filter, with alkaline nitrate and carbonate; the coherent gold is then weighed.—The terchloride of gold serves also for the detection (and estimation) of teroxide of antimony when present with antimonious acid, for example, in the antimoniate of teroxide of antimony (antimonious acid,  $\text{SbO}_3$ ,  $\text{SbO}_5$ ). The detection of teroxide of antimony in the presence of antimonious acid is however more easily effected by nitrate of silver. A solution of teroxide of antimony in caustic alkali, gives with nitrate of silver a deep black precipitate, which does not dissolve in ammonia; a solution of antimoniate of potassa, on the other hand, gives a yellowish-white precipitate of antimoniate of silver, which, if free alkali be present, is mixed with brown oxide of silver; both are completely soluble in ammonia. In order to recognise teroxide of antimony in the presence of antimonious acid, the compound is fused for a short time with hydrate of potassa in a silver crucible, dissolved in water, nitrate of silver added, and subsequently ammonia; if a black precipitate remains undissolved, teroxide of antimony was present, of which the smallest traces are thus indicated. By long fusion with

(1) Ann. Ch. Pharm. LXIX, 363.

(2) Pogg. Ann. LXXVII, 110; Berl. Acad. Ber. 1849, 165; J. Pr. Chem. XLIX, 222; Ann. Ch. Pharm. LXXII, 340; Instit. 1849, 411.

hydrate of potassa the teroxide of antimony is converted into antimonic acid. Terchloride of gold likewise gives a black precipitate in an alkaline solution of teroxide of antimony; with antimoniate of potassa only an insignificant black precipitate is produced after very long standing. A hydrochloric solution of teroxide of antimony is, after a time, so completely precipitated by oxalic acid, that the filtrate is free from antimony; a hydrochloric solution of antimonic acid gives with oxalic acid only a few flocks. Tartaric acid prevents the precipitation of teroxide of antimony by oxalic acid.

Antimony.

In the quantitative determination of teroxide of antimony and antimonic acid, the whole of the antimony present is first determined in one portion of the compound, and in another, the teroxide of antimony by means of terchloride of gold.—H. Rose states that solutions of antimony containing hydrochloric acid, easily lose some antimony in the form of chloride when rapidly evaporated; the sulphur-compounds of antimony always dissolve in hot concentrated hydrochloric acid as terchloride; if the compound contains more sulphur than corresponds to the tersulphide of antimony, this excess remains behind in a pure state after long digestion with hydrochloric acid; from the weight of this residue the composition of the sulphur-compound is determined.

**Separation of Antimony from Tin.**—H. Rose has recently improved the method adopted by him, and described in the Annual Report for 1847 and 1848 (Vol. II, p. 331, *et seq.*), for the separation of antimony and tin; on account of the partial solubility of antimoniate of soda in water, he now employs dilute spirit to separate it from the stannate of soda. The oxides of the two metals retained for some time at a red heat, in fusion, with excess of hydrate of soda in a silver crucible, are exhausted with water, rinsed into a beaker, and the liquid mixed with  $\frac{1}{2}$  of its volume of alcohol of sp. gr. 0.83, in which the stannate of soda is entirely dissolved, whilst the antimoniate is easily deposited. The latter is washed, at first with a mixture of equal volumes of alcohol and water, and at last with a mixture of three volumes of alcohol and one volume of water, until the filtrate acidulated with sulphuric acid no longer gives a precipitate of sulphide of tin when tested with sulphuretted hydrogen. It is advantageous to mix the dilute spirit with a little carbonate of soda.

**Separation of Antimony, Tin and Arsenic.**—In order to separate antimony, tin and arsenic, H. Rose converts them into oxides by means of strong nitric acid, and fuses these with eight or nine parts of hydrate of soda in a silver crucible. The antimoniate of soda is separated, as described above, by dilute alcohol. The filtrate is acidified with hydrochloric acid, completely precipitated by sulphuretted hydrogen, and the sulphides collected upon a weighed filter. (If after long standing and warming with sulphuretted hydro-



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of anti-  
mony, tin  
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arsenic.

gen a fresh precipitate appears, it consists only of sulphide of arsenic, and may be collected separately). The sulphides of tin and arsenic are separated (as stated at page 413) by heating the mixed precipitates in an atmosphere of sulphuretted hydrogen, the former being afterwards converted by roasting into binoxide of tin, the latter into arsenic acid, by means of nitric acid and chlorate of potassa.

**Lead.**—For the rapid estimation of very small quantities of lead, Horsford(1) proposes to precipitate with sulphuretted hydrogen an equal volume of a solution of acetate of lead, the amount of lead in which is diminished according to a certain scale (0.1—0.01—0.001—0.0001—0.00001 grm.), and to compare the amount of the precipitate with that of the sulphide of lead precipitated by sulphuretted hydrogen, from a known quantity of the solution under examination previously mixed with some acetate of potassa. If the solution, without concentration, gives no precipitate, it contains less than  $\frac{1}{1000000}$  of lead; it is then evaporated to a given volume and again tested; if organic matter be present the solution is evaporated to dryness, the residue ignited, dissolved in nitric acid, the solution mixed with some acetate of potassa, and diluted to a given volume.

Ebelmen(2) has proposed the employment of sulphuretted hydrogen for the quantitative separation of several metals in the dry way; this method is based upon the difference in the solubility and volatility of the sulphides formed. His experiments relate to the following metals.

**Separation of Manganese from Nickel and Cobalt.**—In order to separate manganese from nickel and cobalt, the weighed mixture of the oxides is introduced into a little boat of porcelain or of platinum, heated to dull redness in a stream of sulphuretted hydrogen, and the sulphides allowed to cool in an atmosphere of the gas. On digesting for some hours with cold dilute hydrochloric acid, only the manganese is dissolved; the sulphides of nickel and cobalt remain behind free from manganese.

**Separation of Manganese from Zinc.**—The separation of manganese from zinc cannot be effected in this way, since sulphide of zinc is soluble in dilute hydrochloric acid, and acetic acid does not remove all the manganese; it is well known that these two metals may be completely separated, by means of sulphuretted hydrogen, in an acetic solution.

**Separation of Iron from Cobalt.**—A mixture of the sulphides of iron and cobalt (prepared by heating their oxides in sulphuretted hydrogen), yields scarcely any iron even to concentrated hydrochloric

(1) Chem. Gaz. 1849, 297.

(2) Ann. Ch. Phys. [3] XXV, 92; J. Pharm. [3] XV, 266; J. Pr. Chem. XLVI, 305; Ann. Ch. Pharm. LXXII, 329; Chem. Gaz. 1849, 82.

acid, on which account the two metals cannot be separated by this process; if the oxide of iron contain manganese, a part of the latter always remains behind with the sulphide of iron.

Separation  
of iron  
from  
cobalt.

**Separation of Iron and several other Metals from Arsenic.**—When compounds of arsenic acid with sesquioxide of iron are heated in sulphuretted hydrogen gas, both metals are converted into sulphides; the sulphide of arsenic is volatilised, while the sulphide of iron remains behind free from arsenic. Ebelmen supposes that in this way also, the separation of arsenic acid from the oxides of nickel, zinc, copper and lead, might be effected.

**Separation of Tin from Arsenic.**—In the same manner, all the arsenic may be volatilised as sulphide from a mixture of arsenic acid and binoxide of tin, and even from a compound of the two, by heating in a stream of sulphuretted hydrogen gas, bisulphide of tin remaining behind, which is converted into binoxide by roasting.—H. Rose(1) likewise recommends, for the separation of arsenic and tin, to heat their sulphides in a stream of sulphuretted hydrogen, and to pass the sulphide of arsenic, which is completely volatilised, into ammonia.

**Separation of Nickel from Cobalt.**—In the separation of nickel from cobalt, Wöhler(2) precipitates the latter, after the separation of nickel by Liebig's method(3), by means of nitrate of suboxide of mercury as nearly neutral as possible, which is added to the solution of cobalticyanide of potassium (carefully neutralised with nitric acid, or even when still alkaline). The white precipitate, which is easily washed, contains all the cobalt as cobalticyanide of mercury, and leaves, when ignited in air, black sesquioxide of cobalt.

**Mercury.**—Marignac(4) finds, in the analysis of the compounds of the oxides of mercury with the acids of nitrogen, that the mercury is more easily determined in the form of oxide, than by reduction with protochloride of tin or hypophosphorous acid. The salt is heated in a glass tube, one end of which is drawn out to a point and dips into water, whilst the other is connected with a gascimeter, by means of which dry air is passed through the heated tube, and in this manner the complete decomposition of the salt is easily effected, without the necessity of employing too high a temperature.

**Analysis of Ashes in General.**—H. Rose(5) has fully described the methods which he adopts in the examination of ashes: to the statements upon this head in the Annual Report for 1847 and 1848, Vol. II,

(1) See page 412.

(2) Ann. Ch. Pharm. LXX, 256.

(3) Annual Report for 1847 and 1848, Vol. II, 234.

(4) See page 403 of the present volume.

(5) Pogg. Ann. LXXVI, 324; J. Pr. Chem. XLVIII, 38; Phil. Mag. [3] XXXV, 15.

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ashes in  
general.

p. 238, we must add that the estimation of the phosphoric acid in the hydrochloric extract of the charcoal, is effected by means of metallic mercury and nitric acid (according to the process described at p. 395). The phosphates are either precipitated by ammonia, and afterwards dissolved in nitric acid, or when no sulphuric acid is present, the hydrochloric solution is evaporated to perfect dryness, the dry mass exhausted with nitric acid, the solution filtered from any silica which may be present, and treated with metallic mercury and nitric acid. Rose proposes the following method, contrived by Fleitmann, of overcoming the objection (founded upon the fusion of the ashes into the crucible, and volatilisation of the alkali combined with phosphoric acid) to the complete incineration of the charcoal, after exhaustion with water and acids, in a stream of oxygen gas. The carbonaceous mass is moistened with a concentrated solution of bichloride of platinum, at first gently heated in a porcelain crucible, and then ignited in a concave platinum lid(1). The coal burns off slowly; complete incineration is accelerated by stirring (2), and when necessary by again moistening with bichloride of platinum. The ash-grey residue thus obtained is ignited in a stream of hydrogen gas, in order entirely to decompose the double salts of the alkaline chlorides with bichloride of platinum, then digested with hydrochloric acid, and the filtrate analysed in the same manner as the hydrochloric extract of the charcoal. The undissolved residue, consisting of platinum, sand and silica, is either first boiled with carbonate of soda to remove the silica, and the platinum and sand are then separated by *aqua-regia*; or the platinum is first extracted with *aqua-regia*, and the residue is then treated with carbonate of (not caustic) soda.

With respect to the form in which the inorganic compounds are contained in vegetable and animal substances, H. Rose(3) has adopted the following views. The processes of assimilation of inorganic compounds in plants and animals exhibit very great diversity. The inorganic substances are taken up into the plants in an oxidised state, but during the growth of the latter, especially in the green parts, a process of deoxidation takes place, which is not merely confined to the carbonic acid, but also extends to the mineral constituents; the intensity of the process of deoxidation is least where it first commences, viz: in those organs of plants which are nearest to the ground. As this process of deoxidation proceeds in the living plant, the phosphates are probably converted into unoxidized com-

(1) The combustion of the coal with the aid of finely divided platinum takes place, apparently only, at a lower temperature, for a red heat in reality exists at that part where oxygen is conveyed by the platinum to the coal.

(2) The stirring of the ashes is, as Th. Saussure has already indicated, injurious.

(3) Pogg. Ann. LXXVI, 305; J. Pr. Chem. XLVIII, 36; Berl. Acad. Ber. 1848, December; Phil. Mag. [3] XXXV, 1; Instit. 1849, 175.

pounds containing, in most cases, phosphorised radicals in combination with the metals of the alkalis and earths. Such parts of plants, therefore, as the seeds, the constituents of which have been exposed during the longest period to the deoxidising influence, contain the greatest amount of unoxidised matters, in which the herb-like parts are comparatively poor. After carbonisation of the organic matter, these deoxidised substances are insoluble in water and hydrochloric acid, and are therefore contained in the charcoal which has been exhausted with these menstrua. Rose calls those organic substances, the inorganic constituents of which are in a state of complete oxidation, *teleoxydic* bodies; pea-, rape- and wheat-straw, as well as several animal substances, are included by him in this class. Those organic substances, the inorganic constituents of which are present partly in an oxidised, partly in an unoxidised condition, he designates *meroxydic* bodies; such are peas, rape-seed and wheat. *Anoxydic* bodies, *i. e.* such organic bodies, the charcoal of which yields nothing to solvents, are found neither among vegetable nor animal substances. In the process of nutrition of animals, the elements of the meroxydic constituents of the vegetable food enter into combination with the oxygen conveyed into the system, and at the same time, of course, the compounds of the "hypothetical phosphorised radicals with metals" are also oxidised. Hence it follows that in the blood, as the material from which the other parts of the body are repaired, a certain amount of completely oxidised salts may be contained, although a large quantity of the above-mentioned hypothetical compounds must still be present. The blood is designated a meroxydic substance, as are also cows'-milk, and the yolk of hens'-eggs. The excrements, bones, bile, and the albumin of hens'-eggs belong, on the other hand, to the teleoxydic class.—Ultimately, H. Rose supposes that perhaps the names anoxydic, meroxydic and teleoxydic bodies, will be applied respectively to substances the inorganic constituents of which consist chiefly of phosphates in an unoxidised, a partly oxidised, or an entirely oxidised condition. In this case the blood will be called anoxydic, but the flesh, on the other hand, a meroxydic substance.—This classification proposed by H. Rose, as well as the methods of investigation founded upon his views, are not likely to be retained. If the inorganic substances be contained in such various forms in a vegetable or animal substances, their condition would be so changed by incineration, or even by carbonisation, that no conclusion with regard to the nature of the uncarbonised substance could be drawn from that of the carbonised portion. But leaving this out of consideration, Strecker(1) has found—and his statement has been confirmed by H. Rose(2)—that chloride of sodium, as well as other salts which were purposely added

(1) Ann. Ch. Pharm. LXXIII, 339.

(2) Pogg. Ann. LXXIX, 398.

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to organic substances before carbonisation (and were not produced by the vegetative process), may be as obstinately retained by the coal as the (according to Rose's view) deoxidised salts of phosphoric acid(1). The consideration of this subject, however, belongs to the next Annual Report.—Respecting the results of single analyses, see the sections on Animal and Agricultural Chemistry.

**Analysis of Ashes of Blood.**—F. Verdeil(2) has arrived at the following process for the analysis of the ashes of blood. The blood is first charred in a porcelain capsule till no more empyreumatic vapour is evolved, the porous coal powdered and incinerated in the muffle, and lastly, the ash heated with nitrate of ammonia, which is dissolved in water and added by degrees. The coal is thus entirely burnt, and the carbonates are converted into nitrates, by which means a complete separation is effected, of the constituents soluble in water, from those which are insoluble. The ash of blood thus prepared, when digested with water and filtered, yields a perfectly neutral solution which contains alkaline phosphates, nitrates and sulphates, as well as metallic chlorides and phosphate of magnesia, whilst phosphate of lime and sesquioxide of iron remain behind. From the aqueous solution all the chlorine and phosphoric acid are precipitated by nitrate of silver. The precipitate, when treated with dilute nitric acid, leaves chloride of silver; from the filtrate the silver is precipitated by means of chloride of potassium, and the phosphoric acid is either calculated from the amount of chloride of silver obtained, or precipitated as phosphate of magnesia-ammonia. From the solution which contains the alkalis, the excess of silver and the sulphuric acid are removed by chloride of barium, the baryta and lime then precipitated by means of carbonate of ammonia and ammonia, the filtrate evaporated and the residue ignited. On treatment with water the magnesia is left, whilst the alkalis dissolve, and are determined as usual. The sesquioxide of iron, the lime, and phosphoric acid are also determined by the usual methods, in the portion of ash which is insoluble in water. For the determination of the lime, the sulphuric and carbonic acids, separate quantities of the ash are employed.

**Analysis of the Ashes of Flesh.**—Fr. Keller(3) pursues the following method in the preparation and analysis of the ashes of animal substances (especially of flesh). He boils the animal matter repeatedly with water, and separates the solution from the residue by pressure. The liquid is evaporated, and the residue charred in a porcelain capsule; after boiling the powdered coal with water the

(1) Also Lehmann's views and hopes (*Lehrbuch der Physiol. Chemie*, 2 Aufl., I, 416) are thus deprived of their foundation.

(2) *Loc. cit.* at page 367 of the present volume.

(3) *Loc. cit.* at page 368 of the present volume.

undissolved portion is completely incinerated in the muffle. The residue of flesh which has been boiled out and pressed, is likewise dried and carbonised, and the coal in a finely divided state, treated for several days with strong nitric acid, after which it very easily burns in the muffle. The nitric solution is evaporated, and the ignited residue repeatedly heated with nitrate of ammonia till all the coal has disappeared. The ashes thus obtained are intimately mixed, and ignited with three or four times their volume of fused hydrate of baryta. From the aqueous solution of the ignited mass the baryta is removed by sulphuric acid or carbonate of ammonia, and the alkalis estimated in the filtrate. The portion insoluble in water, which contains all the phosphoric acid, is dissolved in the least possible quantity of nitric acid, the sulphate of baryta which separates is weighed, and the phosphate of sesquioxide of iron precipitated by acetate of ammonia: from the acetic solution the total amount of phosphoric acid is separated by acetate of lead. After the decomposition of the washed phosphate of lead by sulphide of ammonium, the phosphoric acid is precipitated from the filtrate by means of sulphate of magnesia. In the solution filtered off from the phosphate of lead, the baryta and oxide of lead are precipitated by sulphuric acid, the filtrate (from which the last traces of lead must be removed by sulphuretted hydrogen) is evaporated, and the lime and magnesia estimated as usual.

Analysis  
of the  
ashes of  
flesh.

**Analysis of the Ashes of Plants.**—Th. Way and G. Ogston(1) have adopted the following process in their numerous published analyses of the ashes of vegetables(2). The substance was incinerated as far as possible at a dull red-heat in a large platinum crucible, a platinum wire being used to stir it from time to time(3). For the determination of the chlorine, sulphuric and carbonic acids, separate quantities were employed. Ashes which were rich in silica or charcoal were mixed with an equal weight of nitrate of baryta and introduced by degrees into a large ignited platinum crucible, by which means the ash became perfectly white, and was afterwards easily decomposed by hydrochloric acid. The silica was then separated as usual, the sulphate of baryta present being taken into consideration. Of the liquid filtered from the silica, one part was devoted to the estimation of alkalis (by addition of baryta-water, and subsequently of carbonate of ammonia, ammonia, &c.); another portion was precipitated with a slight excess of sulphuric acid (since the quantity of nitrate of baryta employed was known, the amount of sulphate of lime adhering to the precipitated sulphate of baryta may be calculated). In a third portion of the filtrate, the phosphate of sesqui-

(1) Journ. of the Royal Agricult. Soc. of England, VIII, Part 1.

(2) See Agricultural Chemistry in this Annual Report.

(3) See page 414.

Analysis  
of the  
ashes of  
plants.

oxide of iron was precipitated by means of acetate of ammonia, then the lime, and lastly, the magnesia; from the remainder, after nearly neutralising with ammonia and adding acetate of ammonia and free acetic acid, the phosphoric acid was precipitated and determined as described at page 397. In ashes which contained little silica or charcoal the same method was followed, omitting the deflagration with nitrate of baryta. In consequence of some doubt having been thrown upon the accuracy of their results by Rose's researches on the constituents of the ashes of animal and vegetable substances, Way and Ogston have made a number of experiments from which they have arrived at the conclusion, that in their process of incineration no other essential element except sulphur is lost by volatilisation.

Caillat(1) states that in plants poor in fleshy parts, as clover, lucerne, sainfoin, the extraction of the inorganic constituents by dilute hydrochloric acid was so successful that the residue which was obtained when 10 grms. of the plant were thus treated was easily combustible, and left only from 18 to 20 milligrms. of ash consisting of silica and sesquioxide of iron. This mode of treatment likewise furnishes a greater quantity of the constituents of the ash, especially of sulphuric acid, than can be obtained by the ordinary process of incineration.

C. Bischof(2) has remarked that in several of the ordinary methods for the analysis of ashes the amount of soda obtained may be too high. This error is ascribed by him [as also by other chemists, especially by Erdmann(3)], partly to the circumstance that carbonate of baryta is somewhat soluble when much chloride of ammonium is present, and, at the boiling-point, decomposes with this salt, forming chloride of barium and carbonate of ammonia; the former, like chloride of sodium, gives with bichloride of platinum an easily soluble double salt. On this account, the alkaline chlorides (which are obtained by precipitating the hydrochloric solution of the ash with baryta-water, removing the excess of baryta by carbonate of ammonia in the presence of ammonia, and evaporating the filtrate), should always, after the volatilisation of the chloride of ammonium, be again tested for alkaline earths, and especially for chloride of barium. Another cause of an erroneous result is found in the want of attention to all the precautions requisite for the complete separation of potassa from soda by means of bichloride of platinum. Bischof, moreover, observed that the ashes of wood contain soda in some combination from which it can be entirely extracted by hydrochloric acid, but not by water. This, doubtless, depends upon the formation of insoluble

(1) *Compt. Rend.* XXIX, 137; *Instist.* 1849, 249; *Phil. Mag.* [3] XXXV, 309; *Dingl. Pol. J.* CXIV, 423.

(2) *J. Pr. Chem.* XLVII, 193, 208.

(3) *Ann. Ch. Pharm.* LIV, 353.

double phosphates and carbonates. The existence of the former has been placed beyond a doubt by H. Rose (see page 157), insoluble double carbonates, containing an alkali together with lime, likewise exist.

Analysis  
of the  
ashes of  
plants.

**Analysis of Soils.**—F. Schulze(1) has published an abstract occupying nearly six closely printed sheets, of a treatise upon the methods which he employs for the examination of arable soils as to their most important physical properties, and for the determination of their constituents. In these processes the author devotes greater attention than has hitherto been paid to the mechanical analysis of soils, the determination of their hygroscopic capacity, their power of retaining water, the absolute weight of a cubic foot of the moist and dry earth, and its specific gravity; the chemical part contains several original methods, which have been brought forward in the endeavour to establish a more reasonable proportion between the time necessary for the analysis of a soil, and the value of the results which it furnishes. It will be sufficient to state here that Schulze determines the carbon contained in a soil in the form of humus, by heating with bichromate of potassa, and measuring the gaseous products of decomposition collected over water saturated with carbonic acid. For the determination of the sesquioxide of iron, Schulze proposes to compare the tint of the hydrochloric extract of the ignited earth, with that of a like volume of solution of sesquichloride of iron of known strength. For the details of the process we must refer to the treatise.

**Determination of Organic Matter in Water.**—Förchhammer(2) proposes to determine the quantity of organic matter contained in well-waters by means of a solution of permanganate of potassa. This is to be added to the water heated to ebullition, so long as the red tint disappears, after which, by comparing the tint of the cold solution with that of distilled water which has been mixed by degrees with the same solution of permanganate of potassa, the excess added is determined. This process is liable, as Förchhammer himself acknowledges, to error, since the organic matters present always require, according to their nature, different quantities of the oxidising agent, and inorganic substances, such as salts of protoxide of iron, which may be present in the water to be examined, also reduce the permanganate.

**Sugar and Starch.**—H. Fehling(3) has described a method for the quantitative estimation of sugar and starch, which is founded upon the behaviour of grape-sugar with an alkaline solution of oxide

(1) J. Pr. Chem. XLVII, 241.

(2) *Instit.* 1849, 383; *Chem. Gaz.* 1849, 407.

(3) Roser's and Wunderlich's *Arch. f. Physiol. Heilk.* 1848, 64; *Ann. Ch. Pharm.* LXXII, 106; *Chem. Gaz.* 1850, 93.



Sugar and  
starch.

of copper, as observed by Trommer and Barreswil. Fehling has applied this reaction to technical purposes for the estimation of sugar in beet-root, grape-juice and urine, as well as of starch in potatoes and corn, and it seems very well adapted for such determinations. The same process was also recommended by Schwarz(1) for the estimation of starch. The alkaline solution of oxide of copper necessary for this experiment is most advantageously prepared, according to Fehling, by mixing a solution of 40 grms. of crystallised sulphate of copper in 160 grms. of water, with another of 160 grms. of neutral tartrate of potassa in a little water, and from 600 to 700 grms. of solution of caustic soda of sp. gr. 1.12.—This mixture is diluted to 1154.4 cubic centimeters at 15°. A litre of the solution of oxide of copper thus prepared contains 34.650 grms. of sulphate of copper, and requires for reduction 5 grms. of dry grape-sugar ( $C_{12}H_{12}O_{12}$ ), or 10 equivs. of sulphate of copper (1247.5) are reduced to suboxide by 1 equiv. of grape-sugar, (180) ( $34.650 : 5 = 1247.5 : 180$  or  $= 6.93 : 1$ ). Thus 10 cubic centimeters of the copper-solution represent 0.05 gm. of dry grape-sugar. For the examination of a solution containing sugar, Fehling dilutes a known weight of it (in grms.) to 10 or 20 times its volume (in cubic centimeters), so that it contains, at most, 1 per cent of sugar; 10 grms. of grape-juice, for example, are diluted to 200 cubic centimeters. On the other hand, 10 cubic centimeters of the copper-solution are diluted with 40 cubic centimeters of water, the solution heated to boiling, and the liquid containing sugar added, until all the copper is perfectly reduced. The precipitate becomes redder and more abundant, and subsides more readily the nearer this point is approached; a test specimen of the filtrate should neither yield any reaction for copper with sulphuretted hydrogen, nor after acidifying, with ferrocyanide of potassium(2). If the filtrate contains excess of sugar it will exhibit a yellowish tint. Since the copper-salt is reduced immediately and in quantity corresponding to the sugar, protracted ebullition of the solution is unnecessary, if it be always maintained at or near the boiling-point. In order to determine cane-sugar by this process, it must be converted into grape-sugar by heating for several hours with sulphuric or tartaric acid. The same remark applies to starch. In order to ascertain whether the conversion is complete, the test is applied from time to time until the quantity of test-solution consumed is constant. 100 parts of grape-sugar ( $C_{12}H_{12}O_{12}$ ) correspond to 95 parts of cane-sugar ( $C_{12}H_{11}O_{11}$ ),

(1) Ann. Ch. Pharm. LXX, 54.

(2) Kersting (Ann. Ch. Pharm. LXX, 252) finds it convenient in this process to make use of a piece of paper moistened with a concentrated solution of ferrocyanide of potassium, and dried. Upon this, a small doubled strip of filter-paper is laid, and the latter touched with a drop of the turbid liquid. The dissolved oxide of copper sinks through, and produces a red stain.

and 90 parts of starch ( $C_{12}H_{10}O_{10}$ ).—Pectin, tannin and mucus, do not affect the results obtained by this method; grape-juice precipitated with acetate of lead furnishes the same amount of sugar as before precipitation; crude apple-juice, on the other hand, yields somewhat more sugar than when precipitated with acetate of lead before testing.—Schwarz prepares the copper-solution by dissolving 50 grms. of bitartrate of potassa, 20 grms. of dry carbonate of soda, and 40 grms. of hydrate of potassa in 200 cubic centimeters of water, and adding 30 grms. of sulphate of copper dissolved in 100 cubic centimeters of water; the mixed solutions are diluted with water to 500 cubic centimeters. Fehling, however, has pointed out that the solution of copper thus prepared is decomposed immediately in the sun-light, and after some time in ordinary day-light, as well as on heating, with separation of suboxide of copper, which renders it inapplicable to these determinations. The copper-solution, prepared according to Fehling's prescription, remained unchanged during two years, and did not decompose when boiled for a long time,

Sugar and  
starch.

**Milk-sugar.**—Poggiale(1) has proposed the employment of the process just described for the determination of the amount of milk-sugar in milk. 20 cubic centimeters of his solution prepared with 10 parts of sulphate of copper, 10 parts of bitartrate of potassa, 30 parts of hydrate of potassa and 200 parts of water (and graduated by means of milk-sugar, not with cane- or grape-sugar), correspond to 0.200 gm. of milk-sugar. 50 or 60 grms. of milk are mixed with a few drops of acetic acid, heated to  $50^{\circ}$  or  $60^{\circ}$ , filtered, and the weight thus obtained (amounting on an average to 923 grms. for 1000 grms. of milk) employed for the estimation of the milk-sugar. 1000 grms. of whey contain, according to Poggiale, as a mean, 57 grms. of sugar of milk, and 1000 grms. of milk yielded as a mean of ten analyses 43.8 butter, 52.7 milk-sugar, 38.0 casein, 2.7 salts and 862.8 water.—Poggiale(2) has also stated that the milk-sugar may be determined with certainty by means of Soleil's saccharometer. For this purpose the whey freed from fat and casein as above, is cleared by addition of acetate of lead, and filtration from the precipitate thus produced. With regard to this optical test of milk, and the similar methods of A. Becquerel for the estimation of albumin in blood, compare page 86; for the saccharometrical methods of Clerget, see page 84.

**Organic Bases.**—Riegel(3) has observed and minutely described the reactions of a great number of natural organic bases. For these,

(1) *Compt. Rend.* XXVIII, 505; *Instit.* 1849, 154; *J. Pharm.* [3] XV, 411; *J. Chim. Méd.* [3] V, 364; *J. Pr. Chem.* XLVII, 134.

(2) *Compt. Rend.* XXVIII, 584; *Instit.* 1849, 145; *J. Pharm.* [3] XV, 413; *J. Pr. Chem.* XLVII, 349.

(3) *Arch. Pharm.* [2] LVIII, 274.

Sulphate  
of cincho-  
nine in  
sulphate  
of quinine.

however, we must refer to the original treatise, which will not admit of any abstract.

**Sulphate of Cinchonine in Sulphate of Quinine.**—O. Henry(1) has modified the process proposed by him for the estimation of sulphate of cinchonine in sulphate of quinine(2), in the following manner. 10 grms. of an average specimen of the suspected sulphate of quinine are triturated with 4 grms. of acetate of baryta, and 60 grms. of water, with addition of a few drops of acetic acid. The mixture solidifies after some moments to a voluminous mass of needles with a silky lustre, which are carefully and rapidly pressed between linen or flannel. The turbid liquid containing all the cinchonine as acetate, is filtered, and afterwards mixed in a flask, with twice its volume of alcohol of 35°, with a slight excess of sulphuric acid, and again filtered. The filtrate is mixed with a decided excess of ammonia, and boiled for a moment. Crystalline flakes of pure cinchonine now separate, which when the liquid has partly cooled, are collected on a weighed filter, and their weight determined. This process yields somewhat too little cinchonine. Henry does not consider an admixture of 1 to 2 per cent of sulphate of cinchonine with sulphate of quinine as an adulteration, since it is hardly possible in the manufacture of the latter salt on a large scale, entirely to exclude it. Henry satisfied himself that his process furnishes results in accordance with those obtained by the use of ether and ammonia, according to Liebig's method.

**Stearin in Wax.**—According to Lebel(3), an adulteration of wax with even  $\frac{1}{10}$  of stearin, may be recognised by dissolving the specimen in two parts of oil, agitating with water, and adding acetate of lead; the precipitate thus obtained is said to exhibit a very high degree of solidity.

**Testing of Opium.**—A. Guillermond(4) recommends the following process; which is certainly inferior in accuracy to that described by Merck(5) for the determination of the quantity of morphine contained in opium. 15 grms. of opium are triturated with 60 grms. of alcohol of 71°, the marc expressed in linen, and again extracted with 40 grms. of alcohol of the same strength. The tinctures thus obtained are mixed with 4 grms. of ammonia, by which the morphine is deposited after 12 hours, together with more or less narcotine, in coloured crystals, upon the walls of the vessel. These crystals are collected upon linen, repeatedly washed with water to remove the meconate of ammonia, and the lighter narcotine crystals separated by

(1) J. Pharm. [3] XVI, 327.

(2) Annual Report for 1847 and 1848, II, 246.

(3) J. Chim. Méd. [3] V, 403.

(4) J. Pharm. [3] XVI, 17.

(5) Geiger and Liebig's Handb. d. Pharm., 5. Aufl., I, 1189.

decantation, from the morphine which quickly subsides when diffused in water. A good specimen will yield in this way from 8 to 10 per cent of crystallised morphine.

Testing  
Indigo.

**Testing of Indigo.**—Reinsch(1) ascertains the quality of indigo by comparing the intensity of the colour of a diluted solution in sulphuric acid, containing a known weight of the indigo, with that of a normal solution which is prepared with a better specimen.

**Reaction for Bile.**—M. S. Schultze(2) has pointed out, that not only bile and the so-called protein-compounds, but also a number of other organic matters, such as liquid vegetable or animal fats, when gently heated with concentrated sulphuric acid and some sugar, give rise to the red colour, upon the production of which the test for bile described by Pettenkofer(3) depends. Schultze is of opinion that this test cannot be employed for the detection of bile, and that it will only allow of the recognition of bile when the absence of protein-compounds has been proved, as, indeed, was originally observed by Pettenkofer himself. Schultze believes that he has, by the following process, isolated the product of decomposition which causes the red colour. The white of a hen's egg, diluted with 5 parts of water and filtered, was gradually mixed with concentrated sulphuric acid till the precipitate which first appeared was redissolved; the clear solution was mixed, at a temperature not exceeding 60°, with several drops of a concentrated solution of cane-sugar, and precipitated after 10 or 15 minutes with ammonia, an excess of the latter being avoided. The violet-coloured precipitate thus obtained dissolves in concentrated sulphuric acid with a purple-red tint; it is also easily soluble in potassa and ammonia, the ammoniacal solution is precipitated by chloride of barium and by acetate of lead.

**Test for the so-called Protein-compounds.**—E. Millon(4) finds that a solution of mercury in an equal weight of concentrated nitric acid, when diluted with some water, becomes (in consequence of the presence of a quantity of the nitrite) a delicate test for a great number of nitrogenised animal substances; in solutions containing only  $\frac{1}{100000}$  of the latter, a more or less intense red colour is produced by the mercury-solution. If the substances to be tested are dissolved in an alkali, or in sulphuric acid, a red colour is produced without formation of a precipitate; the products of their decomposition by means of nitric acid or chlorine, however, no longer exhibit this reaction. The red colour is most distinct when the liquid is heated to 60° or 70°, or even to ebullition.

(1) Jahrb. Pr. Pharm. XVIII, 248.

(2) Ann. Ch. Pharm. LXXI, 266; J. Pharm. [3] XVII, 145; Chem. Gaz. 1850, 98.

(3) Ann. Ch. Pharm. LII, 92.

(4) Compt. Rend. XXVIII, 40; Instit. 1849, 29; J. Pr. Chem. XLVII, 350; Ann. Ch. Pharm. LXXII, 349.

Analysis  
of  
blood.

**Analysis of Blood.**—Fr. Hinterberger(1) has made several analyses of blood, with the intention of comparing the degrees of accuracy to be attained by the use of the various methods hitherto proposed. In his treatise, he gives a description of all the known methods for the analysis of blood, and selects for comparison, from among those requiring the coagulated blood, that described by Scherer(2), from those which direct that the fibrin should be separated by whipping, that of Becquerel and Rodier(3), and from those which allow of the direct determination of the blood-globules, that proposed by Höfle(4).

He finds that the amount of fibrin is smaller when it is determined by whipping, than when the coagulum is expressed, whilst in the latter case, the amount of albumin is diminished (which is also the case in a marked manner with Höfle's method). Scherer's method of analysis yields the smallest, and Höfle's the largest amount of blood-globules; the extractive matters, fats and salts, are most accurately determined according to Scherer's method. (Gorup-Besanez(5) prefers Scherer's process for analysing the coagulated blood, on account of its cleanliness, facility and rapidity of execution, but he considers that the estimation of the fibrin is best effected by whipping; since the accuracy of the determination of the blood-globules is less injured thereby).—The following synopsis of Hinterberger's analyses, made according to the various methods above-mentioned, will best show to what extent the numbers obtained for the various constituents differ among themselves. (B. and R. indicates the method of Becquerel and Rodier, Sch. that of Scherer, and H. that of Höfle.)

	Sheep's blood.	Human blood. (Rheumatis- mus.)	Human blood. (Angina tonsill.)	Human blood. (Morbus Brightii.)
Water B. and R.	838·64	774·59	789·71	—
Sch.	860·04	—	791·29	—
H.	—	773·54	796·86	—
Fibrin B. and R.	3·19	1·93	2·35	0·97
Sch.	4·32	—	2·82	1·04
H.	—	1·93	2·35	—
Albumin B. and R.	55·68	76·59	75·31	68·57
Sch.	53·36	—	73·63	61·93
H.	—	22·27	43·85	—
Blood-globules B. and R.	89·51	136·26	123·92	132·40
Sch.	72·22	—	110·25	88·64
H.	—	152·74	130·32	—

(1) Griesinger's Arch. f. Physiol. Heilk. VIII, 603.

(2) Otto, Beitr. zu d. Anal. des Gesunden Bluts. Würzb. 1848, 5.

(3) Höfle, Chemie u. Mikroskop am Krankenbett. Erlang. 1848, 131.

(4) Ibid. p. 132.

(5) Griesinger's Arch. f. Physiol. Heilk. VIII, 617.

Moleschott(1) has published some remarks upon a source of error in Andral-Gavarret's method of analysing blood, and Henle(2) upon some misinterpretations of which his method for calculating the composition of the clot from the analysis of the blood is capable.

**Apparatus.**—Schenkel and Rieckher(3) have described an "improved" Marsh's apparatus. It admits of three different gases (hydrogen, carbonic acid, and hydrosulphuric acid) being passed through the same chloride of calcium tube. This is effected by glass stop-cocks; but it is scarcely probable that this novel form of Marsh's apparatus will be frequently employed.—E. Kopp(4) has devised an apparatus for continuous extraction, which is founded on the same principle as those described by Payen and by Mohr(5).—M. N. Bloch(6) has constructed an intermittent syphon intended for washing precipitates; E. C. Summers(7), an apparatus for the same purpose.

**Sea-water.**—According to J. Davy(8), carbonate of lime is chiefly found in the sea-water near the coast; water collected at but small distances from the land contains only trifling quantities of this salt. The water of Carlisle Bay in Barbados contains 1 part of carbonate of lime in 10,000 parts; in the sea-water collected in the neighbourhood of the volcanic island of Fayal scarcely a trace was found. White(9) is of opinion that the bottom of the sea must exert an analogous action to that produced by the coast, and believes that if the sea-water at great distances from the land be free from carbonate of lime, this absence must be confined to the surface of the sea.—Wilson(10) has confirmed his former statements, that sea-water (especially that of the German Ocean) contains fluorine; the same element has been observed by Forchhammer(11) in sea-water collected near Copenhagen.—According to Malaguti, Durocher and Sarzcaud(12) a small quantity of silver is found in sea-salt, in sea-

(1) Zeitschr. f. ration. Medic. von Henle u. Pfeufer, VII, 228.

(2) Ibid. VII, 404.

(3) Jahrb. Pr. Pharm. XIX, 259.

(4) Laur. u. Gerh. C. R. 1849, 305.

(5) Comp. Practical Pharmacy, by Mohr and Redwood, p. 89. London: Taylor, Walton, and Maberley, 1849.

(6) Ann. Ch. Phys. [3] XXVI, 126; J. Pharm. [3] XV, 409.

(7) Phil. Mag. [3] XXXV, 96.

(8) Phil. Mag. [3] XXXV, 232; Edinburgh New Philos. Journ. XLVII, 320; Instit. 1849, 325; Chem. Gaz. 1849, 268 (in abstr.); Arch. Ph. Nat. XIII, 159.

(9) Phil. Mag. [3] XXXV, 308.

(10) Chem. Gaz. 1849, 404; Instit. 1849, 316.

(11) Instit. 1849, 317.

(12) Ann. Ch. Phys. [3] XXVIII, 129; J. Pr. Chem. XLIX, 421; Compt. Rend. XXIX, 780 (in abstr.); Instit. 1849, 409; Arch. Ph. Nat. XIII, 55.

Sea-water. water itself (1 milligram. in 100 litres), in different varieties of fucus (in *fucus serratus* and *ceramoides* at least  $\frac{1}{1000000}$ ), in chemical products in whose manufacture sea-salt is employed (soda and hydrochloric acid for instance), in the ashes of land-plants (the insoluble part of the ash contains more silver than the soluble one), in the ash of ox-blood, in rock salt and perhaps even in coal. They inferred the presence of silver in these substances from the fact of lead fused with them leaving on the cupel a more perceptible quantity of silver than the same kind of lead subjected to the same process without these substances. They state that the ash of the above-named species of fucus, and hence also the sea-water, contains moreover lead ( $\frac{1}{1000000}$ ) and copper. These metals are said to exist in the sea-water in the form of chlorides, and to arise from the native sulphides of the metals by the action of the chlorine in the water.

For Usiglio's researches on the composition of the various deposits from sea-water in consequence of evaporation, we refer to our Report on Technical Chemistry; we have communicated in the last Report (II, 264), an analysis of the sea-waters taken in the neighbourhood of Cetto(1) from a preliminary notice published at an earlier period.

**Water of the Dead Sea.**—The water of the Dead Sea has been analysed by R. F. Marchand(2), by Th. J. and W. Herapath(3), and by J. C. Booth and A. Muckle(4). Marchand did not find any iodine; Th. J. and W. Herapath doubtful traces of iodine and nitric acid. Composition of the water in 100 parts:

Sp. grav. . . . .	Marchand. 1·185	Th. J. and W. Herapath. 1·172	Booth and Muckle. 1·227
Chloride of calcium . . . .	2·894	2·455	3·108
Chloride of magnesium . . . .	10·543	7·822	14·590
Chloride of potassium . . . .	1·398	1·217	0·659
Chloride of sodium . . . . .	6·578	12·110	7·855
Chloride of aluminum . . . .	0·018	0·056	—
Chloride of ammonium . . . .	—	0·006	—
Chloride of manganese . . . .	—	0·006	—
Chloride of iron . . . . .	—	0·003	—
Bromide of potassium . . . .	—	—	0·037
Bromide of magnesium . . . .	0·251	0·251	—
Sulphate of lime . . . . .	0·088	0·068	0·070
Carbonate of lime . . . . .	—	trace	—
Silica . . . . .	0·003	trace	—
Nitrogenous organic substance .	—	0·002	—
Bituminous substance . . . .	—	trace	—
Total of the fixed constituents .	21·729	24·056	26·419
Directly determined . . . . .	21·671	24·048	—

(1) In detail, Ann. Ch. Phys. [3] XXVII, 92.

(2) J. Pr. Chem. XLVII, 353 (with a synopsis of the former analyses of this water); Pogg. Ann. LXXVI, 462 (in abstr.); Ann. Ch. Pharm. LXXII, 220; J. Pharm. [3] XVI, 225.

(3) Chem. Soc. Qu. J. II, 336.

(4) Narrative of the United States Expedition to the River Jordan and the Dead Sea; by W. F. Lynch. Philadelphia, 1849, 509.

**Well-, Spring- and River-waters.**—W. West, Forchhammer, Daubeny and Rogers(1) have declared for the view that all mineral and thermal waters invariably contain nitrogen.

**In Germany.**—Th. Bromeis(2) has examined the waters of a sulphuretted brine on the western slope of the *Lindener Berg* near Hanover(A). F. Müller(3) has published an analysis of the brines at *Stadt Sulza* in Sachsen-Weimar, but without stating the method which he employed. The springs examined are the *Mühlenquelle* (B); this water contained moreover chloride of lithium; the *Kunstgraben-quelle*(C) and the *Leopoldsquelle*(D). In all these waters he found a certain quantity of sesquichloride of aluminium. The mother-liquor of the salt which he likewise examined contained moreover iodide of sodium. R. F. Marchand(4) has examined the water of the mineral spring at *Dölau* near Halle (E, contains, moreover, traces of phosphoric acid, alumina and lithia); O. L. Erdmann(5) the brine of *Wittekind* near Halle (F); Leber(6) the water of the new mineral-spring at *Salzschlirf* near Fulda (G, contains traces of chloride of lithium, phosphate of lime, carbonate of protoxide of manganese, extractive matter and chloride of ammonium); G. Wolf(7) the water of the thermal spring at *Gastein* (H, 100 vols. of the water contain 4·865 of gas; 100 vols. of this gas contain 5·074 of carbonic acid, 27·110 of oxygen, and 67·816 of nitrogen). The following table exhibits the composition in 1000 parts of water.

Well-,  
spring-  
and  
river-  
waters.

Sp. gr.	A.	B.	C.	D.	E.	F.	G.	H.
	1·0808	?	?	?	1·0075	1·025	1·0178	1·0004
Carbonate of lime	0·5515	0·212	0·113	0·175	0·0163	0·100	1·0344	0·047406
„ magnesin	—	—	—	—	—	—	0·0386	0·003601
„ protoxide of iron	—	0·616	0·310	0·417	0·0266	—	0·0514	0·006769
„ „ manganese	—	—	—	—	—	—	—	0·002618
„ soda	—	—	—	—	—	—	—	0·005242
Sulphate of lime	3·4360	1·714	2·516	1·098	0·4454	1·004	1·6846	—
„ potassa	1·8413	—	—	—	0·0563	—	0·2305	0·001412
„ soda	2·4369	3·755	3·444	1·916	0·3831	—	0·2417	0·197511
Basic-phosphate of alumina	—	—	—	—	—	—	—	0·005374
Chloride of sodium	93·6850	28·574	26·216	39·416	8·6983	35·454	11·1481	0·047645
„ potassium	—	0·120	0·110	0·318	—	—	—	—
„ magnesium	3·1290	1·171	0·824	0·274	0·0425	0·744	1·3692	—
„ calcium	—	0·840	0·642	0·316	—	0·396	—	—
Iodide of magnesium	—	—	—	—	0·0007	—	0·0055	—
Bromide of magnesium	—	trace	trace	trace	0·0046	0·006	0·0058	—
Silica	0·0678	—	—	—	0·0291	—	0·0073	0·031458
Alumina	—	—	—	—	—	—	0·1157	—
Crenic acid	—	trace	trace	trace	—	—	trace	—
Apocrenic acid	—	trace	trace	trace	—	—	trace	—
Asphalt-like substance	0·1861	—	—	—	—	—	—	—
Total of the fixed constituents	105·3336	37·002	34·175	43·930	9·7009	37·704	15·9328	0·349036
Free carbonic acid	0·6708	much	much	much	0·178	—	1·9412	0·006688
Hydrosulphuric acid	0·0702	—	—	—	—	—	—	—

(1) Instit. 1849, 399.

(2) Ann. Ch. Pharm. LXIX, 115.

(3) Arch. Pharm. [2] LVII, 165.

(4) J. Pr. Chem. XLVI, 427.

(5) J. Pr. Chem. XLVI, 313.

(6) Pharm. Centr. 1849, 791.

(7) From *Österr. Jahrb. d. Med.*, January to June, 1848, in *Schmidt's Jahrb. der Ges. Med.* LXII, 145.



Well-  
spring-  
and  
river-  
waters.  
In  
Germany.

G. Bischof(1) has investigated the spring of the watering place of *Oeynhaus* near *Neusalzwerk* in Westphalia (A), which rises from a boring 2220 feet deep (under the level of the sea). Schrötter(2) has communicated the analysis of the mineral water of *Mödling* (B) (contains in 16 ounces 1.86 Vienna cubic inches of free carbonic acid). Quadrat(3) has analysed the mineral water of *Sternberg* in Bohemia, viz.: that of the *Selinenquelle* (C) and of the *Heinrichbrunnen* (D); both these waters contain traces of basic phosphate of alumina, protoxide of manganese, arsenious acid, and indifferent organic substances. The following table exhibits the quantity of the constituents in 16 ounces of water expressed in grains.

Sp. gr. . . . .	A. ?	B. ?	C. 1.0003	D. 1.0006
Carbonate of lime . . . .	6.670	1.99718	2.8578*	2.8280*
„ magnesia . . . .	3.856	0.02258	0.3262*	0.5908*
„ protox. of iron . . . .	0.513	0.04493	0.2486*	0.2417*
„ protox. of manganese . . . .	0.010	—	—	—
Sulphate of soda . . . .	—	0.46356	0.2252	0.1430
„ potassa . . . .	0.361	—	0.1194	0.1154
„ lime . . . .	22.999	0.50189	0.2798	0.1837
„ magnesia . . . .	19.997	2.35676	0.4185	0.4998
Chloride of sodium . . . .	256.396	0.08801	—	—
„ magnesium . . . .	8.281	—	0.1338	0.0565
Silica . . . .	0.357	0.07219	0.0983	0.0888
Total of the fixed constituents . . . .	319.140	5.54710	4.7106	4.7477
Free carbonic acid . . . .	—	—	4.0015	2.7032

\* These numbers represent bicarbonates.

Waltl(4) found in 36 ounces of the mineral water of *Kellberg*, near Passau, 1.90 grains of crenic acid, 0.50 silica, 1.08 carbonate and crenate of protoxide of iron, 1.66 of sulphate of magnesia, and 1.60 cubic inches of carbonic acid.—A. Barth(5) found in 1 litre of the so-called *Jod-Soda-Quelle*, or *Johann-Georgenquelle* of *Krankenheil* near Tölz in Bavaria, 0.0280 grm. of sulphate of lime, 0.1049 carbonate of lime, 0.0522 carbonate of soda, 0.4620 chloride of sodium, 0.0045 iodide of sodium, and traces of silica and organic substances; total amount 0.6516 grm.; result of determination 0.6205. The sp. gr. of this water is 1.0006. Bley(6) found in an ounce of the deposit obtained by evaporating the *Krankenheil* water, as it occurs in commerce, 0.3456 grm. of iodide of sodium. Ac-

(1) Froriep's Notizen aus d. Natur- u. Heilkunde, 1849, Nr. 203.

(2) Wien. Acad. Ber. 5. Heft, 50.

(3) From d. Prager Vierteljahrschrift, 1849, 2, in J. Pr. Chem. L, 49.

(4) Repert. Pharm. [3] III, 116.

(5) J. Pr. Chem. XLVII, 404.

(6) Arch. Pharm. [2] LX, 284.

cording to Fresenius(1) 100 parts of this salt contain 25·800 of water, 73·523 of constituents soluble in water (1·298 sulphate of potassa, 9·113 sulphate of soda, 34·327 neutral carbonate of soda, 6·743 sesquicarbonate of soda, 20·259 chloride of sodium, 0·198 iodide of sodium, 4·475 silicate of soda, 1·110 humate of soda, traces of bromide of sodium, chloride of lithium, crenic and apocrenic acid), and 0·639 constituents insoluble in water (0·428 carbonate of lime, 0·109 carbonate of magnesia, 0·054 phosphate of lime, 0·048 phosphate of sesquioxide of iron, a trace of a peculiar resin having the odour of benzoe). Barth(2) found the residues attained on evaporating the various springs of Krankenheil varied very much in composition; he was unable to detect any phosphoric acid.

Sigwart(3) contradicts, like Fehling(4), Rieckher's(5) statement that 1 cwt. of the concentrated mother-liquor of the brine of *Friedrichshall* contain as much as 1160 grains, and of that of *Clemenshall* (Offenau) as much as 2205 grains of iodine; even the most concentrated mother-liquors exhibited only doubtful traces of iodine.—Sigwart found bromine in the mineral water of *Cannstatt* and in that of *Berg*; he observed iodine in the sulphuretted water of *Sebastianweiler* (between Tübingen and Hechingen), and somewhat larger quantities of this element in the water of *Boll*; neither bromine nor iodine was found in the mineral waters of *Teinach* and of *Wildbad*.

H. Becker(6) found arsenic in the alluvial soil in the neighbourhood of the Weser mountain; he conjectures that the arsenic is present in the form of arsenite of lime or of sesquioxide of iron, and partially, perhaps, in the form of sulphide of arsenic.

**In France.**—According to Lassaigue(7), the ochry deposit of the mineral water of *Wattweiler* (Department of the Upper Rhine) contains 2·8 per cent of arsenic, which exists in the form of arseniate of sesquioxide of iron. In the ochry deposit of the mineral water of *Royat* (Department of Puy-de-Dôme), he states that 0·3 per cent of arsenic are present, likewise in the form of an arseniate. Both varieties of deposits produced no poisonous effect upon animals.

Girardin(8) has examined the mineral water of *Rançon* (A); Marcel de Serres and L. Figuier(9) have published an analysis

(1) J. Pr. Chem. XLIX, 146.

(2) J. Pr. Chem. XLIX, 313.

(3) From d. Würtemb. Naturw. Jahreshften, IV. 269, in J. Pr. Chem. XLVII, 231.

(4) Annual Report for 1847 and 1848, II, 255-301.

(5) Annual Report for 1847 and 1848, II, 257.

(6) Arch. Pharm. [2] LVII, 129.

(7) J. Chim. Méd. [3] V, 489.

(8) J. Pharm. [3] XV, 115.

(9) J. Pharm. [3] XVI, 184.

Well-,  
spring-  
and  
river-  
waters.  
In  
France.

of the mineral water of *Balaruc* (Department of Hérault), which coincides with the one of *Figuiet* and *Mialhe* we communicated in our last Annual Report, II, 261.—The mineral water of *Villecelle* near *Lamalou* (Department Hérault), has been analysed (B) by *Audouard*(1) (according to this analysis, 1 litre of the water contains, moreover, 0.005 grm. of carbonate of ammonia, and 100 litres 0.0024 of arsenious acid) and by *O. Henry*(2) (C).—*Lefort*(3) has examined a mineral spring (*Enclos des Célestins*) near *Vichy* (D), which contains traces of strontia, lithia, iodine, bromine, and arsenic; sp. gr. 1.0068. The following table exhibits the amount of fixed constituents (expressed in grammes) and of gases (expressed in litres) contained in 1 litre of the various waters.

	A.	B.		C.	D.
Carb. of lime . . .	0.202	0.228	Bicarb. of lime . . .	0.678	0.610
„ magnesia . . .	—	0.072	„ magnesia . . .		
„ soda . . .	—	0.368	„ soda . . .		
„ protox. of mang. . .	—	0.006	„ potassa . . .	trace	trace
„ „ iron . . .	0.024	0.002	„ protox. of iron . . .	0.315	0.031
Crenate „ „ . . .			Crenate and apocrenate . . .		
Sulphate of lime . . .	0.015	0.027	of iron . . .	0.065	0.173
„ soda . . .	—	0.043	Sulphate of soda . . .		
Chloride of sodium . . .	—	0.009	„ lime . . .		
„ calcium . . .	0.011	—	Chloride of sodium . . .	0.010	0.667
„ magnesium . . .	0.006	—	„ potassium . . .	—	trace
Phosphate of alumina . . .	—	0.003	Silica . . .	0.025	0.017
Silica . . .	trace	0.018	Silicate of alumina . . .		
Alumina . . .	—	0.006	Manganese . . .		
Organic matter . . .	trace	0.024	Phosphate of alumina . . .	—	0.092
Crenic acid . . .	trace	—	Silicate of soda . . .		
Apocrenic acid . . .	trace	—	Organic matter . . .		
Total of the fixed constituents . . .	0.258	1.026	Total of the fixed constituents . . .	—	6.213
Total directly determined . . .	—	—	Total directly determined . . .	1.229	—
Free carbonic acid . . .	—	1.687	Free carbonic acid . . .	about 0.5	0.52
Nitrogen . . .	—	0.008	Nitrogen . . .	not determ.	—

*Legrip*(4) has examined the mineral water of *Chauxmaix* (Department of Creuse). 10 litres of the water (sp. gr. 1.0008) left, on evaporation, 5.80 grms. of residu, exhibiting the percentage A; the deposit of the spring exhibited the composition B.

(1) J. Chim. Méd. [3] V, 466.

(2) J. Chim. Méd. [3] V, 468.

(3) J. Pharm. [3] XVI, 14. For an analysis of this water by *O. Henry*, we refer to our last Report, Vol. II, 263.

(4) J. Chim. Méd. [3] V, 514.

	A.	B.
Sulphate of lime . . . . .	3.75	7.50
„ potassa . . . . .	8.50	—
Chloride of sodium . . . . .	4.25	—
Carbonate of protoxide of iron . . . . .	10.50	11.25
„ soda . . . . .	19.25	—
„ lime . . . . .	31.25	42.50
Sesquioxide of iron . . . . .	—	20.25
Alumina . . . . .	1.75	1.25
Silica . . . . .	14.00	8.75
Organic matter . . . . .	5.50	2.50
Loss . . . . .	1.25	—

Well,  
spring-  
and  
river-  
waters  
in  
France.

Filhol(1) is of opinion that the rapid decomposition of the hot sulphuretted waters of the Pyrenees is due to the formation of polysulphide of sodium; he states that the protosulphide of sodium is decomposed in such a manner as to yield more rapidly oxide of sodium, than oxides of sulphur.

**In Italy. (Organic Substances in Sulphuretted Waters.)** — Bonjean(2) has investigated the gelatinous organic substance which is deposited from sulphuretted waters when in contact with the atmosphere, and which has been designated as *barègin*, *plombièrin*, or *glairin*. He states that the *glairin* of the sulphuretted water of *Aix*, in Savoy, is white, but slightly soluble in water, and more soluble in concentrated acids, from which it may be precipitated in bluish-white flakes. It is free from iodine, and contains but little nitrogen. In contact with the air, it assumes a greyish colour; chlorine, bromine and nitric acid reproduce the white colour. When kept in water it is free from any smell, but in contact with the air it rapidly evolves a bad odour; when dried at 40° it is perfectly inodorous, and has the appearance of horn.—Bonjean applies the term *glairidin* to an organic substance which is deposited from mixtures of sulphuretted and other waters (rain-water, for instance); it is of a dark-grey, remains inodorous even in contact with air, and is not decolourised by acids; nor does it assume a horn-like appearance by desiccation; it contains traces of iodine.—If the *glairin* of sulphuretted water, containing no other water in admixture, be collected, the first water which drains off deposits violet plates of *zoiodin*. The latter is inodorous and tasteless; it is not altered in contact with air and light, and is insoluble in water; with nitric acid and hydrochloric acid it becomes yellowish-red, with the alkalis brown; it is not decolourised by chlorine.

(1) Ann. Ch. Phys. [3] XXVII, 490.

(2) J. Pharm. [3] XV, 321; J. Chim. Méd. [3] V, 545 (in abstr.); Phil. Mag. [3] XXXV, 75.

Well-,  
spring-  
and  
river-  
waters.  
in  
England.

**In England.**—J. Mitchel(1) has analysed the water (A) of the Hampstead Water-works Company, in London; (it is pumped from a boring at *Hampstead*; Brande(2) the water of the new Well at the Mint, in *London*, which is 426 feet deep; E. T. Bennett(3) the water of the *Thames*, near *Greenwich* (C); Th. J. Herapath(4) the mineral water of *Kingswood*, near Bristol (D). The following table gives the quantity of fixed constituents (expressed in grains) and of free carbonic acid (expressed in English cubic inches) contained in 1 gallon (the space filled by 70,000 grains of water).

Sp. gr.	A.	B.	C.	D.
	1·00065	1·0007	1·00116	1·00507
Sulphate of potassa	3·2781	—	1·3710	—
„ soda	4·8113	13·14	3·9224	122·7600
„ magnesia	—	—	0·5475	129·7520
„ lime	4·4202	—	—	75·1160
Nitrate of lime	—	—	—	0·0960
Chloride of sodium	17·7581	10·53	—	60·8240
„ magnesium	—	—	1·1482	0·4800
„ potassium	—	—	—	0·8384
„ calcium	—	—	1·6272	—
Iodide of sodium	—	—	—	0·0720
Carbonate of lime	3·8325	3·50	14·3997	31·7328
„ magnesia	3·4083	1·50	—	trace
„ soda	—	8·63	—	—
Silica	0·2859	0·50	0·7958	0·9600
Phosphate of lime	0·2767	—	—	trace
Phosphoric acid	—	trace	trace	—
Alumina	—	—	trace	trace
Iron	trace	trace	trace	trace
Manganese	trace	—	—	—
Organic matter	—	trace	4·0810	23·9920
Crenic acid	0·1659	—	—	—
Apocrenic acid	0·0840	—	—	—
Extractive matter	1·7199	—	—	—
Apocrenate of magnesia	—	—	—	1·6240
Crenate of magnesia	—	—	—	1·1600
Total of the fixed constituents	40·0409	37·80	27·8928	449·4072
Total directly determined	40·11	37·50	28·0387	450·0480
Free carbonic acid	4·39	—	19·8535	32·9936

(1) Chem. Soc. Qu. J. II, 32; Ann. Ch. Pharm. LXXI, 359 (in abstr.); J. Pr. Chem. L, 51.

(2) Chem. Soc. Qu. J. II, 345.

(3) Chem. Soc. Qu. J. II, 195; J. Pr. Chem. L, 50; for G. F. Clark's Analysis of the Thames water near Twickenham, we refer to Annual Report for 1847 and 1848, Vol. II, 254.

(4) Chem. Soc. Qu. J. II, 200; J. Pr. Chem. L, 51.

**In Cyprus.**—Landerer(1) has made some statements regarding the mineral springs in Cyprus.

**In Iceland.**—Bickell(2) has examined several specimens from the Iceland springs which had been brought home by Bunsen, namely: the water of the Badhstofa-spring, at *Reykir* (A), and of the Scribla-spring, near *Reykholt* (B); the siliceous deposit of the Badhstofa-spring (C) and of the Scribla-spring (D). In the following table A and B give the amount of the constituents contained in one litre of the waters expressed in grammes, C and D the percentage composition of the siliceous deposits.

Well-,  
spring-  
and  
river-  
waters.  
In  
Cyprus.

	A.	B.	C.	D.
Sulphur . . . . .	0·0036	—	—	—
Chlorine . . . . .	0·1426	0·0814	—	—
Carbonic acid . . . . .	0·1019	0·0780	—	—
Sulphuric acid . . . . .	0·0464	0·0549	0·31	2·49
Silica . . . . .	0·2373	0·1663	91·56	88·26
Soda . . . . .	0·0881	0·0956	0·19	0·11
Potassa . . . . .	0·0385	0·0318	0·16	0·11
Lime . . . . .	0·0124	0·0042	0·33	0·29
Magnesia . . . . .	0·0211	0·0107	0·47	trace
Sesquioxide of iron . . . . .	—	—	0·18	3·26
Alumina . . . . .	—	—	1·04	0·69
Water . . . . .			5·76	4·79

**In Java.**—A. Waitz(3) has published the analyses of several mineral waters from Java; we refer to the paper, for the origin of the various waters is for the most part very uncertain.

**In Canada.**—T. S. Hunt(4) has examined several waters from the western districts of Canada: namely, the acid water (A) of the *Tuskarora-well*, in the neighbourhood of Brantford; the sulphuretted water of *Charlottetown* (B), near Port-Dover, at Lake Erie; and the *Lancaster-brine* (C). Composition in 1000 parts:

(1) Arch. Pharm. [2] LX, 28.

(2) Ann. Ch. Pharm. LXX, 290. For a former analysis of the water of the Badhstofa-spring, by Damour, we refer to the Annual Report for 1847 and 1848, II, 266.

(3) Arch. Pharm. [2] LIX, 1.

(4) Sill. Am. J. [2] VIII, 364. A former communication, by Hunt, on the water A is found in Sill. Am. J. [2] VII, 175. An analysis of the mother-liquor of the salt-works near Freeport, in Pennsylvania, has been communicated by Boyé (Sill. Am. J. [2] VII, 74).

Well,  
spring-  
and  
river-  
waters.  
In  
Canada.

Sp. grav. . . . .	A. 1·0056	B. 1·0027	C. 1·0291
Sulphate of potassa . . . . .	0·0608	0·0510	—
„ soda . . . . .	0·0502	0·4718	—
„ lime . . . . .	0·7752	1·1267	0·7769
„ magnesia . . . . .	0·1539	0·4351	—
„ protoxide of iron . . . . .	0·3639	—	—
„ alumina . . . . .	0·4681	—	—
Phosphoric acid . . . . .	trace	—	—
Sulphuric acid . . . . .	4·2895	—	—
Carbonate of lime . . . . .	—	0·3056	—
„ magnesia . . . . .	—	0·0180	—
„ protoxide of iron . . . . .	—	trace	—
Bromide of magnesium . . . . .	—	—	0·1031
Chloride of magnesium . . . . .	—	0·0878	5·0737
„ sodium . . . . .	—	—	17·8280
„ potassium . . . . .	—	—	0·0920
„ calcium . . . . .	—	—	12·8027
Total amount of fixed constituents . . . . .		2·4944	36·6764
Hydrosulphuric acid . . . . .	trace	0·1776	—
Free carbonic acid . . . . .	—	0·1535	—

# TECHNICAL CHEMISTRY.

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**Metals. Iron.**—Chenot(1) has communicated to the *Société d'Encouragement* a new process for smelting iron ores. He cements them in a case with the aid of aqueous vapour decomposed by coal at a red-heat. However, this method, and the subsequent working of the spongy iron under the hammer, did not prove very successful.

**Metals.  
Iron.**

From investigations made at an earlier period, F. C. Wrightson(2) had arrived at the conclusion that the employment of the hot-blast increases the amount of phosphorus present in the iron, and, in consequence, the cold-short of the latter. With the intention of prosecuting this observation further, and of determining the composition of pig-iron more accurately than it has been done hitherto, Wrightson has made a series of analyses of the furnace products. For this purpose he dissolved the finely-divided iron in hydrochloric acid, filtered the solution, and determined the weight of the washed residue, which consisted of graphite together with small quantities of silica, sesquioxide of iron, lime &c. The amount of carbon in this residue was determined and calculated as existing in the uncombined state. The filtered solution was employed for the estimation of the metals. The sulphur and phosphorus were estimated in a special experiment by dissolving the iron in nitric acid and precipitating the sulphuric acid with chloride of barium; after removing the excess of baryta with sulphuric acid, the filtered liquid was mixed with tartrate of ammonia and excess of ammonia, and the sesquioxide of iron separated by sulphuretted hydrogen. The filtrate from the sulphide of iron contained the phosphoric acid together with the alkalis and earths. The phosphoric acid was converted into the tribasic modification by fusion with a little carbonate of potassa, and was then precipitated and weighed as phosphate of magnesia-ammonia. By this method the following results were obtained (those designated by the same numbers refer to specimens of iron obtained from the same ore):

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(1) Bull. Soc. d'Enc. 1849, 496; Dingl. Pol. J. CXIV, 431.

(2) Chem. Gaz. 1849, 478, and (Appendix thereto) 1850, 27; Phil. Mag. [3] XXXVI, 68; Dingl. Pol. J. CXVI, 207; preliminary notice, Chem. Gaz. 1849, 410; Instit. 1849, 407; Dingl. Pol. J. CXIV, 319.



Iron.

## Specimens of cast-iron from the iron-ore of South Staffordshire.

	Cold-blast.				Hot-blast.					
	1.	2.	3.	4.	1.	2.	3.	4.	5.	6.
Residue insol. in hydrochloric acid.			3.71*	4.05†	7.93‡	6.51§	5.54	6.83¶		
Combined carbon	1.87	0.95	—	—	—	—	—	—	1.77	2.72
Uncombined carb.	1.92	1.67	—	—	—	—	—	—	0.49	0.26
Silica	1.30	0.51	—	—	—	—	—	—	0.31	0.11
Manganese	1.12	1.16	0.33	0.94	1.71	1.30	0.72	0.62	0.34	0.54
Cobalt	trace	—	—	trace	—	—	—	—	—	—
Chromium	trace	—	—	—	—	—	—	—	—	—
Calcium	0.05	trace	0.25	0.16	0.11	trace	0.34	0.06	0.10	0.06
Sodium	0.16	trace	0.30	0.34	0.41	0.37	0.39	0.30	0.19	0.14
Potassium	trace	0.42	—	—	—	—	trace	trace	—	—
Sulphur	trace	0.11	0.05	trace	0.07	trace	trace	trace	trace	trace
Phosphorus	0.21	0.36	0.03	0.36	0.54	?	0.07	0.40	0.12	0.37
Iron	94.10	96.57	94.53	94.42	89.53	92.98	93.84	92.90	95.23	95.80
Total	100.73	101.75	99.20	100.27	100.30	101.16	100.90	101.11	98.55	100.00

\* Containing 1.98 carbon.

† Containing 2.73 carbon.

‡ Containing 3.27 carbon.

§ Containing 3.11 carbon.

|| Containing 2.98 carbon.

¶ Containing 0.87 carbon.

These results confirm the statement that hot-blast iron contains somewhat more phosphorus than cold-blast iron from the same ore, and show moreover that the metals of the alkalis occur more abundantly in pig-iron than was hitherto supposed. We are not informed whence arise the differences, frequently very considerable (even as high as  $1\frac{3}{4}$  per cent), in the total percentage amount of the constituents, nor upon which of the determinations the error falls. Neither is it stated whether the silicon is present exclusively as silica or not.—Wrightson has prepared from three of the above-mentioned specimens of iron, somewhat larger quantities of the residue insoluble in hydrochloric acid, which he has submitted to a closer though still incomplete examination. According to him this residue contains only the free carbon (graphite), and not that which was combined with the iron, since this unites with the nascent hydrogen to form the well-known odorous compound. The carbon was determined by combustion with chromate of lead, and the silica by fusion with a mixture of nitre and carbonate of soda, with the following results :

The numbers correspond to those in the above table.	Cold-blast iron.		6.
	1.	2.	
Carbon.	32.36•	34.51	11.76
Iron	—	—	79.52
Sesquioxide of iron	19.00	37.50	—
Silica	40.00	22.19	9.48
Traces of alumina, lime, &c.	—	—	
Water	8.64	4.70	—
Loss			—
	100.00	98.90	100.76

The proportions of iron and carbon in No. 6 approach somewhat the formula  $\text{Fe}_3\text{C}_2$ . The presence of so large a quantity of sesquioxide of iron in the other two cases raises some doubts, and demands farther proof. The analysis of the ores from which the specimens of iron submitted to examination were obtained, showed the presence of phosphoric acid in every case; in some specimens this constituent amounted only to a trace, in others to between  $\frac{1}{2}$  and 1 per cent.—Rinmann(1) states that he has found phosphorus in all the cold-short specimens of Swedish bar-iron.(2)

With regard to the so-called cubes of titanium in the blast-furnaces, see p. 180.

W. A. Miller(3) has compared a specimen (A) of hot-blast pig-iron, reduced from hæmatite (out of Lancashire) by charcoal, with the product B obtained by treating the former with powdered red-iron stone; annexed to these he gives an analysis of a red-short bar iron C, and D, one of cold-short iron.

Sp. grav. . . . .	A. 7·684	B. 7·718	C. 7·426	D. 7·921
Carbon { combined	2·217	0·434	} 0·245	0·275
{ uncombined	0·538	0·446		
Silicium . . . . .	0·951	0·409	0·232	0·288
Aluminum . . . . .	trace	trace	0*	0
Manganese . . . . .	0	0	0	0
Titanium . . . . .	0	0	0	0
Arsenic . . . . .	0	0	0	0
Chromium . . . . .	—	—	0	0
Copper . . . . .	—	—	0	0·041
Sulphur . . . . .	0·015	—	0·016	trace
Phosphorus . . . . .	trace	trace	0·011	0·337
Calcium . . . . .	—	—	trace	0
Potassium . . . . .	—	—	trace	trace
Iron . . . . .	95·777	98·711	99·496	99·059
Sand . . . . .	0·502	—	—	—
Total	100·000	100·000	100·000	100·000

\* Where 0 occurs in the table, it indicates that a metal has been expressly sought for, but in vain.

**Copper.**—F. Field(4) has examined the copper-slugs from the smelting furnaces of the *South American and Mexican Company* in Chili, where the smelting is effected by Napier's method. The ores

(1) Chem. Gaz. 1849, 405; Instit. 1849, 317; Dingl. Pol. J. CXIV, 319.

(2) Also cobalt occurs in cast iron.—Analyses recently made in the Giessen laboratory have shown the existence of more than 1 per cent of cobalt in a specimen of cast iron.

(3) Rep. Brit. Assoc. for 1848, Notices and Abstracts, 55.

(4) Chem. Soc. Qu. J. II, 220.

**Copper.** are fused with 15 per cent of lime, together with chloride of sodium ; the slags differ in every case, according to the amount of the latter employed. When 20 per cent of chloride of sodium are added, the slag fuses to a clear, transparent, homogeneous liquid which separates, on cooling, into two distinct well-defined layers, an upper amorphous layer, A, and a lower crystalline layer, B. The amorphous slag is vitreous, with conchoidal fracture, of a fine dark-green, almost black colour, which, in contact with metallic iron, passes into red. It is rapidly and entirely dissolved by *aqua regia*, and even by hydrochloric acid: not so, however, the lower slag (*sharp slag*), which requires for this purpose a protracted fusion with alkaline carbonate; it possesses a crystalline texture throughout. When 10 per cent of chloride of sodium are added, the slag does not separate by crystallisation; it then forms a fine veined mass, in colour very different from C, of considerable hardness and susceptible of a high polish. A structure very similar to that of A was exhibited by a slag from a furnace at Coquimbo, in the druse cavities of which were found some well-defined cubical crystals D.

	A.	B.	C.	D.
Silica. . .	49.26	49.60	42.20	35.60
Soda . . .	7.93	0.70	3.44	—
Lime. . .	7.84	1.23	6.43	4.48
Magnesia . . .	2.62	0.11	2.14	0.16
Alumina . . .	12.37	14.00	10.80	6.85
Protoxide of iron . . .	18.60	—	31.00	50.46
Sesquioxide of iron . . .	—	32.94	—	—
Oxide of copper . . .	0.70	1.06	0.45	2.32
Manganese . . .	trace	trace	—	—
Chloride of sodium . . .	0.48	0.43	0.34	—
Sulphur . . .	trace	—	1.43	—
Loss . . .	0.20	—	0.21	0.13
Insoluble matter . . .	—	—	1.56	—
	100.00	100.07	100.00	100.00

It is not expressly stated whether the iron existed in B as sesquioxide or protoxide. Although his investigation is not yet completed, Field considers himself justified in asserting that the chemical and physical properties of the slag depend as much upon the duration and degree of the smelting-heat, as upon the proportion by weight of the flux.

Respecting the improvements in smelting copper-ores, see the specifications of patents by C. Low(1), J. Mitchell, H. Alderson and Th. Warriner(2).

(1) Chem. Gaz. 1849, 47.

(2) Chem. Gaz. 1849, 413.

Percy(1) has examined copper which had been fused with phosphorus, and found in two experiments 0.93 and 2.41 of phosphorus, together with 1.99 and 2.41 of iron (from the iron stirring-rod). The presence of the phosphorus was indicated by an increase of hardness without a proportional diminution of the malleability.

Reboulleau(2) has discovered a method of preparing a blue arseniate of copper which may be used as a pigment. For this purpose he fuses together equal weights of ordinary arseniate of protoxide of copper and arseniate of potassa, and adds to the melting mass  $\frac{1}{5}$  its weight of nitre. Binoxide of nitrogen is evolved, and a fine blue compound formed, from which the potassa-salts are washed out by water. Reboulleau believes that the copper exists in this blue salt in the form of some higher oxide which is formed at the expense of the nitre, and is stable, even at the ordinary temperature, only when combined with arsenic acid; no farther experiments, however, are adduced in support of this opinion.—The discoverer recommends this substance only as a water-colour, since, when rubbed with oil, it soon passes into green.

**Tin.**—For the preparation of Mosaic gold the following process is recommended(3). An amalgam of 2 parts of tin and 1 of mercury is prepared in a hot crucible, and triturated with 1 part of sal-ammoniac and 1 of flowers of sulphur; the mixture is sublimed in a glass flask upon the sand-bath. On breaking the flask after the operation, the sublimate is found to consist superficially of sal-ammoniac, then of a layer of cinnabar, and lastly of a layer of mosaic gold.

Respecting Banka tin, see p. 188.

**Lead.**—E. N. Horsford(4) states that leaden pipes are liable to two different species of incrustation, according to the nature of the water passing through them: in one case this incrustation consists merely of suboxide which is absolutely insoluble; in the other, of a combination of oxide of lead with carbonic acid and water, which dissolves in from 7000 to 10,000 times its weight of water; even this solubility, however, is annulled by the presence of sulphuric acid, sesquioxide of iron, or of organic matter.

**Zinc.**—Schauefele(5) has investigated the action exerted upon vessels of zinc and galvanised iron by brandy, wine, vinegar, broth, milk, olive-oil, well-water, distilled water, Selters water and brine. He found that all these liquids (with exception of olive-oil) attack such vessels, and that the galvanised iron is more rapidly and effec-

(1) Chem. Gaz. 1849, 410; Dingl. Pol. J. CXIV, 354; Instit. 1849, 407.

(2) Instit. 1849, 241; Compt. Rend. XXIX, 125 (in abstr.)

(3) From the Hannöv. Notizbl. in Arch. Pharm. [2] LIX, 200. This process is essentially the same as that proposed by Woulfe (L. Gmelin's Handb. der Chemie, 4. Aufl., IV, 75).

(4) Loc. cit. p. 412.

(5) From the J. Chim. Méd. in Dingl. Pol. J. CXI, 144.

Zinc.

tually acted upon than the zinc; both metals were always simultaneously dissolved, and in far larger quantity than by any of the other liquids, by vinegar.

**silver.**—Malaguti and Durocher(1) have communicated some observations respecting the distribution of silver throughout the ores of various metals, and its extraction from these ores. They are of opinion that the test in the humid way is inapplicable to the detection of very small traces of silver, whilst, by cupellation, they were able to detect a quantity of silver-leaf weighing 0.000062 grm. mixed with 30 grms. of lead (they do not touch upon the question, closely connected however with this subject, why it is practically found that a loss, even as high as 0.0018, is experienced in cupel assays); by this mode of testing they have proved that, with a few exceptions (only 10 out of 200 cases), the ores of the various metals always contain silver. Many ores contain only traces, and the silver is always very unequally distributed. In general the oxides and salts are said to be the poorest in silver, whilst the sulphides are particularly argentiferous; amongst the latter the poorest are the ferruginous sulphides, whilst lead-glance, zinc-blende and copper-pyrites contain the most silver.

From their experiments upon the roasting of the metallic sulphides, Malaguti and Durocher conclude that the amount of silver which is volatilised in this process is much greater than it is usually assumed to be; for example, in roasting zinc-blende, one half of the silver is volatilised. Part of the silver thus sublimed is found in the flue of the condensing chamber. Experiments, partly synthetical, with a view to ascertain in what state the silver exists in the natural ores composed of metallic sulphides, have rendered it probable that in most cases it is present in the form of sulphide of silver. Nevertheless, in eleven cases out of thirty-two, part of the silver could be directly extracted by mercury. That the silver cannot exist in these ores in the form of chloride or bromide is sufficiently proved by the behaviour of these haloid salts towards the metallic sulphides. According to the observations of Malaguti and Durocher, the chloride and bromide of silver undergo a double decomposition with the monosulphides ( $\text{PbS}$ ,  $\text{SnS}$ ,  $\text{CdS}$  &c.); sulphides similar to  $\text{SnS}_2$  are reduced in contact with these salts to monosulphides, whilst metallic sulphides which are still capable of abstracting sulphur (*e.g.*  $\text{Cu}_2\text{S}$ ) act partly as reducing agents upon the chloride and bromide of silver, and partly by double decomposition. Similar decompositions take place with the metallic arsenides and with the combinations of the sulphides of antimony and arsenic with other metallic sulphides, both in the wet and in the dry way; in many of these cases, the decomposition is energetic and decided, whilst in others (as with sulphide of mercury and sulphide

(1) *Compt. Rend.* XXIX, 689; *Instit.* 1849, 393; *Dingl. Pol. J.* CXV, 276.

of cobalt) it is effected with difficulty, or even sometimes not at all. Chloride of silver is likewise decomposed when ignited with quartz, felspar, clay and other silicates. (This last fact has been long known, and has given rise to the application of chloride of silver in glass- and porcelain-painting.)

Silver.

In a second paper(1) Malaguti and Durocher have extended their observations to the amalgamation of silver ores, and especially to the influence of the gangues and of the soluble salts upon the process. With regard to the gangues they find that the process is more troublesome when they are of a fatty and clayey nature than when poor and quartz. They consider the presence of carbonate of lime and of the foreign metallic sulphides ( $\text{PbS}$ ,  $\text{ZnS}$ , &c.) particularly disadvantageous in this process, whilst on the other hand they regard the presence of salts (of common salt amongst others) as favourable to the reduction of the chloride of silver. From a series of comparative experiments they have concluded that by the employment of mercury alone the chloride of silver is less easily converted into amalgam than metallic silver, and even than sulphide of silver, but that the amalgamation is remarkably facilitated by metallic iron. The great length of the American process of amalgamation is chiefly due to the presence of foreign metallic sulphides, since the conversion of the sulphide of silver into chloride takes place only after the corresponding change has been effected in the other sulphides. The decomposition of the sulphide of silver is effected exclusively by the chloride of copper (when the sulphur, according to the supply of air, is either separated in the free state, or is converted into sulphuric acid), and not by the common salt, which serves only to accelerate the process.

Malaguti and Durocher have endeavoured to discover a method of reducing the sulphide of silver directly, without previous conversion into chloride, and believe that this may be effected by treating the ores with nascent hydrogen, or still better, with metallic copper and sulphate of copper, green vitriol or alum. Finally, they bear testimony to the practical utility of the method mentioned in Vol. II, p. 277 of the preceding Annual Report, for extracting the silver with common salt, without the use of mercury.

**Gold.**—Allain and Bartenbach(2) have examined the pyrites from the copper mines of Chessy and Sain-Bel, and find it composed of sulphur, iron, zinc (about 8 per cent), copper (about 5 per cent), arsenic, gold (at least 0.0001 of its weight), and silica. They are of opinion that the following process will allow of the advantageous extraction of the gold. After the ore has been freed from sulphur and arsenic by roasting, the oxides of copper and zinc are extracted

(1) *Compt. Rend.* XXIX, 735; *Instit.* 1849, 402; *Dingl. Pol. J.* CXV, 279.

(2) *Compt. Rend.* XXIX, 152; *Instit.* 1849, 250; *Phil. Mag.* [3] XXXV, 309; *Dingl. Pol. J.* CXIII, 293; *J. Pr. Chem.* XLVIII, 232.

Gold.

with sulphuric acid, and the residue (consisting of sesquioxide of iron, silica and gold), is digested with solution of chlorine, in the cold, which leaves the sesquioxide of iron untouched. After some hours the gold is said to be completely dissolved, and the metal can be reduced according to one of the known methods. The two Perrets(1) confirm the presence of gold in these pyrites, but contend that it is present in quantity sufficiently considerable for extraction, and lay claim to the above process for effecting this.

Duflos(2) has published some experiments upon the separation of gold from the arsenic-residues of Reichenstein. He found that the gold could not be extracted from them by means of ferrocyanide of potassium (cyanide of potassium was left out of consideration on account of its high price), but was dissolved with comparative ease by means of chlorine-water, or of a solution of chloride of lime in 50 parts of water acidulated with hydrochloric acid. Several experiments which agreed among themselves gave  $\frac{1}{4}$  loth ( $\frac{1}{4}$  oz.) gold in 1 ctr. (110lbs.) : with respect to the vessels to be made choice of in practice, farther experiments showed that oaken rolling-casks were entirely unfitted for the purpose, since their use very considerably diminished the produce. Duflos, therefore, recommends that the arsenic-residues be treated with solution of chlorine, by the method of displacement in clay-vessels shaped like a sugar-loaf, and arranged on earthen supports.

**Electro-gilding.**—Max, Duke of Leuchtenberg(3) has examined the precipitate formed at the anode during the process of electro-gilding on a large scale. At a certain period of the process (when about half of the gold has been deposited from the solution in cyanide of potassium), there collects at the platinum anode a red crystalline powder(A), which at first was supposed to contain gold, and was therefore collected. The formation of a precipitate(B), which had a similar appearance, from a solution of cyanide of copper, raised some doubts regarding the presence of gold; the percentage results of the analyses are as follows :

	Potassium.	Copper.	Iron.	Cyanogen.	Corresponding to :
A.	18.08	17.30	15.21	49.87	2 K, 2 Cu, 2 Fe, 7 Cy.
B.	10.41	24.94	15.17	49.28	K, 3 Cu, 2 Fe, 7 Cy.

Although both these analyses conduct directly to the above formulæ, the author leaves it nevertheless undetermined whether these substances are definite compounds, or only mixtures of the three

(1) Compt. Rend. XXIX, 700.

(2) J. Pr. Chem. XLVIII, 65.

(3) Petersb. Acad. Bull. VIII, 113; Dingl. Pol. J. CXIV, 356; J. Pr. Chem. XLVIII, 372.

cyanides. They were completely dissolved only by sulphuric acid, and not by other mineral acids.

Electro-  
gilding.

The exhausted gold-solution furnishes on evaporation a saline mass, which, for the purpose of investigation, was fused in a cast-iron pan. A mixture of reduced metals was thus obtained, which, when washed and fused in a crucible, formed a very brittle regulus which contained 53.25 per cent of copper, 15.69 lead, 22.79 tin, 1.54 iron, 0.90 silver, 1.40 zinc, and 4.00 of gold.

**Cobalt. Nickel.**—Respecting cobalt and Thénard's blue, see p. 190.

Louyet(1) has described the process which is followed in a manufactory at Birmingham for obtaining cobalt and nickel from speiss (Hungarian, containing about 6 per cent nickel, and 3 per cent cobalt). The ore is first fused with chalk and fluor-spar, the slag rejected, and the smalt thus obtained thrown into cold water, ground to powder, and roasted in a reverberatory furnace as long as arsenious acid is evolved (12 hours). The roasted mass then dissolves almost entirely in hydrochloric acid. The acid solution is diluted with water, mixed with chloride of lime to peroxidise the iron, and with milk of lime to precipitate the sesquioxide of iron together with the arsenic; this precipitate (which is of no farther use) is washed, and sulphuretted hydrogen passed through the clear liquid until this re-agent has been added in excess, *i. e.* till a small filtered portion gives a black precipitate on addition of ammonia. The precipitate produced by sulphuretted hydrogen (which is likewise useless) is washed with water impregnated with this gas, and the cobalt precipitated from the filtrate by solution of chloride of lime; the liquid from which the cobalt has been separated is mixed with milk of lime to precipitate the nickel. The cobalt precipitate is sent into the market, after a gentle ignition, as sesquioxide, or when strongly ignited, as protoxide (85 fr. per kilogr.), and is said to be very pure. The nickel precipitate is reduced by charcoal, and the nickel sold to the manufacturers of nickel silver (at 35 fr. per kilogr.).

**Alloys.**—Guettier(2) has prepared a great number of alloys, particularly of 1. tin with zinc, 2. tin with lead, 3. tin with zinc and lead, 4. zinc with lead, 5. copper with tin, 6. copper with zinc, 7. copper with lead, 8. copper with tin and zinc, 9. copper with tin, zinc and lead, in different proportions, and has subjected them to examination, keeping in view the properties likely to prove valuable in practice, especially colour, lustre, hardness, susceptibility of polish, tenacity and flexibility, behaviour on casting, hammering and filing; he has

(1) *Monit. Ind.* 1849, 1309; *J. Pharm.* [3] XV, 204; *Instit.* 1849, 6; *Dingl. Pol. J.* CXI, 272; *J. Pr. Chem.* XLVI, 244.

(2) *Monit. Industr.* 1848, No. 1255 to 1258, and No. 1261 to 1268; *Dingl. Pol. J.* CXIV, 128, 196, 279.



**Alloys.** also compared the different degrees of facility with which these alloys may be prepared. For the ample details of this investigation, we must refer to the original treatise.

**Parting of Gold by Sulphuric Acid.**—Max Pettenkofer has continued his investigation, which has been already mentioned(1) on the subject of gold-refining,(2) with a view to the farther extraction of the slag obtained in the refining with nitre. The investigation is divided into the examination of the slag itself, and of the methods proposed for its farther extraction.

These slags are of a greyish-brown, often of a greenish-grey colour, possess a vitreous fracture, and where they have been in contact with the regulus, exhibit a thin, light-yellow film of gold; they form, even at a high temperature, so thick a liquid, that the globules of metal diffused throughout the mass are only partly deposited in the crucible. When exposed to the air the slags gradually deliquesce, but when treated with water dissolve rapidly with evolution of heat, forming a very caustic liquid which is free from gold, and deposits a considerable quantity of a grey powder. The slags contain globules of gold and silver mechanically mixed, and moreover, in chemical combination, the potassa of the nitre, the constituents of the refining-pot (silica, alumina, lime, &c.), together with the insoluble metallic compounds formed by the action of sulphuric acid in the refining process (sulphate of lead, basic sulphate of iron, sulphate of copper), and lastly, the metallic oxides formed by the action of the nitre upon the *spongy gold* (oxides of gold, platinum and palladium, also osmic acid). The presence of these substances affords an explanation of the circumstance, that the weight of the slags remains always pretty equal to that of the nitre employed. It has been ascertained by several years' experience of this process in the refining establishment at Munich, that the dry *spongy gold* when fused with nitre, loses on an average 2 per cent of its weight. In one experiment on the small, and two on the large scale, Pettenkofer found in the washed slag 0.82, 1.25 and 0.67 of gold; as a mean, therefore, 0.9 per cent of the *spongy gold*, together with 0.171, 0.098 and 0.116, as a mean 0.128 per cent of platinum. The proportion of this latter in the slag is so far increased, that its quantity sometimes amounts to  $\frac{1}{3}$  that of the gold. Pettenkofer readily explains the great variations in the amount of gold contained in the slag, when a constant quantity of nitre ( $\frac{1}{16}$  of the spongy gold) is employed, by the difference in the temperature, which would allow more or less of the noble metal to remain suspended, and by the variation in the quantity of the other constituents dissolved by the slag. The amount of gold contained in the slag is greatest when

(1) Dingl. Pol. J. CXI, 357.

(2) See Annual Report for 1847 and 1848, II, 280.

large quantities of the material are employed, and less if smaller quantities are used, the fusion being conducted, as is usually the case, in crucibles of the same size. Pettenkofer finds that it is not advantageous to keep the mass in fusion till all the regulus has subsided, for experience teaches that in this case, the silver, instead of remaining, as usual, in the slag, goes down with the regulus, which then instead of 0.001, as in other cases, remains as much as 0.002 below the standard.

Parting of  
gold by  
sulphuric  
acid.

Pettenkofer proposes the following method as that best adapted for recovering the gold in practice. The slags collected from several operations are treated with water, and allowed to stand for 8 or 12 days till they have so far disintegrated as to furnish a fine paste, to which, for every 8 parts of dry slag, 2 parts of litharge, 1 part of bitartrate of potassa, 4 parts of dry soda, and 2 parts of powdered glass must be added. After the mixture has been dried in a copper or iron pan, it is projected by small portions at a time into a red-hot crucible, and exposed to a gradually increasing heat till it is in a state of tranquil fusion. If sufficient time has been allowed for this operation, there will be found on cooling, beneath the grey slag, a distinct regulus of lead containing the gold and platinum. On cupelling this, the metal obtained is granulated and dissolved in *aqua regia* in a retort, which should be furnished with a receiver to retain the platinum and gold which are carried off by the vapour. The heat is continued till the nitric acid is completely expelled, the solution thus obtained is filtered from the residue (chloride of silver and chloride of lead) into a porcelain capsule, and precipitated by heating with sulphate of iron. The gold, which is thus precipitated in spongy masses, is separated from the liquid by decantation, washed, and fused with  $\frac{1}{2}$  of nitre (to remove a trace of palladium). It is then pure gold. The solution decanted from the gold is precipitated with metallic iron, the precipitate (consisting, in great measure, of platinum) boiled out with nitric acid, is then dissolved in *aqua regia*, and precipitated as ammonio-chloride of platinum. An attempt to decompose the slag with sulphuric acid presented insuperable difficulties in practice.

**Tinning.**—According to Thomas and Delisse(1), if organic matter be present, the dilute acid which is employed to clear the surface of iron previously to tinning, dissolves merely the layer of oxide without in the least affecting the metal, thus removing an important difficulty in tinning, especially in the manufacture of tinplate. They found, amongst other substances, sugar, gum and vegetable extractive matters well adapted for this purpose.—Lüdersdorff's(2) experiments have shown that in this process, which he

(1) Mechanic's Mag., Dec. 1848; Dingl. Pol. J. CXI, 271.

(2) Dingl. Pol. J. CXII, 460.

**Tinning.** highly recommends, the addition of a little wood- or coal-tar is quite sufficient.

Sorel(1) recommends for the same purpose, and especially for the tinning of cast iron, the surface of which when acted upon by the acid is liable to be contaminated with carbon, an addition of a soluble tin- or copper-salt to the diluted acid in the proportion of from 2 to 4 per cent.

**Tin-plate, Use of the Refuse.**—E. Schunck(2) has published three methods of recovering the tin and iron from the refuse in the manufacture of tin-plate. 1. This refuse may be treated with a boiling solution of *hepar sulphuris* (prepared with soda), which produces a solution of bisulphide of tin in sulphide of sodium. This solution is evaporated to crystallisation, the crystals drained, pressed, and exposed to a gradually increasing heat in a reverberatory furnace (such as is used in smelting the ordinary tin-ore). The bisulphide of tin is first converted into binoxide by roasting, and is then reduced by means of charcoal and soda, or lime. The slag, consisting chiefly of sulphide of sodium, may be again used for the preparation of *hepar sulphuris*. 2. The refuse is thrown into a hot solution of protoxide of lead in caustic soda or potassa, or 3. into a mixture of chromate of potassa and caustic alkali. In the former case, metallic lead is separated as a black powder, in the latter, green sesquioxide of chromium is precipitated. In both cases a solution of an alkaline stannate is obtained; this is allowed to crystallise, and the crystals are reduced in a reverberatory furnace; the slag thus obtained consists of carbonate of soda, and may be used again.

By the first of these processes, to which Schunck accords the preference, the iron is obtained perfectly free from tin; by the others, nearly all the tin is removed. In any case the iron is well washed, arranged in parcels, and welded.

**Malleable Brass.**—During the last two years specimens have been sent from this country into Germany of an alloy similar to brass, which, at a red heat, is said to behave like malleable iron. This valuable character has been confirmed by the statement of the "Gewerbeverein" of Lower Austria, by whose commission there were obtained in the analysis of an English specimen, 65.03 of copper and 34.76 zinc. Machts, the proprietor of a factory in Hanover, found that an alloy made by him of 60 parts of copper and 40 of zinc even surpassed the English metal in malleability. Elsner(3) has lately analysed a specimen of this last alloy, known as *yellow metal*, and found 60.16 copper and 39.71 zinc. These

(1) Monit. Industr. 1849, No. 1319; Dingl. Pol. J. CXII, 121; J. Chim. Méd. [3] V, 721.

(2) Chem. Gaz. 1849, 327; Lond. J. of Arts, 1849, 15; Dingl. Pol. J. CXIII, 372.

(3) From the Verh. Gew. Bef. Pr., in Dingl. Pol. J. CXIII, 434.

numbers approximate to the composition  $\text{Cu}_3\text{Zn}_2$  (59.4 per cent copper and 40.6 zinc). A bar made by his direction of 3 parts of copper and 2 of zinc, was capable of being beaten into a key. In colour, the alloy stands between tombac and brass; it has a powerful lustre, a fine dense texture, great (absolute?) strength, and a sp. gr. of 8.44 at  $10^\circ$ . The mean of the specific gravities of its constituents is 8.08, showing that some contraction has taken place.

Malleable  
brass.

**Alloys for Railway-bars.**—For the use of railway engineers the following alloys are recommended as having been employed for several years in Belgium(1): 1. In those cases where the objects are much exposed to friction: 20 parts of copper, 4 of tin, 0.5 of antimony, and 0.25 of lead. 2. For objects which are intended to resist violent shocks: 20 parts of copper, 6 of zinc, and 1 of tin. 3. For those which are exposed to heat: 17 parts of copper, 1 of zinc, 0.5 of tin, and 0.25 of lead. The copper is added to the fused mass containing the other metals.

**Speculum for Telescopes.**—The speculum(2) of Lord Rosse's celebrated telescope weighs about 90 ctrs., and is composed of copper with somewhat less than half its weight of tin. (The alloy  $\text{Cu}_4\text{Sn}$  would consist of 68 per cent) of copper, and 31.7 of tin; it is evident that the speculum-metal is a true chemical compound, since slight deviations in the composition of the mixture, produced a perceptible effect upon the properties of the alloy.)

**Cadmium-amalgam.**—Evans(3) prepares an amalgam of tin and cadmium for stopping teeth; this amalgam has an advantage over the copper-amalgam, since it does not blacken in the mouth. According to F. Varrentrapp(4) it should be prepared by dissolving 1 part of cadmium and 2 of tin in an excess of mercury, and squeezing the amalgam through leather. This amalgam softens without crumbling when kneaded, and hardens again after some time.

**Britannia-metal.**—Köller(5) found in a specimen of *Britannia metal* (the well-known alloy resembling silver, and much used for tea-pots, &c.), 85.72 per cent of tin, 10.39 of antimony, 2.91 of zinc, and 0.98 of copper.

**Type-metal.**—J. Moser(6) has examined two specimens of type-metal, which differed in quality as well as in fracture and colour. They consisted chiefly of lead and antimony, containing besides, only small quantities of copper and zinc. Since the two alloys were not quite homogeneous, Moser was enabled to select for analysis speci-

(1) Dingl. Pol. J. CXIII, 463.

(2) Loc. cit. p. 92.

(3) J. Pharm. [3] XVI, 445; Dingl. Pol. J. CXV, 397.

(4) Ann. Ch. Pharm. LXXIII, 256; Dingl. Pol. J. CXV, 466.

(5) From the Verhandl. Niederöstr. G. V., in Dingl. Pol. J. CIV, 335.

(6) Wien. Acad. Ber. 1849, Febr., 85.

Type-metal.

mens which were free from the two last-named metals. In the best of the two alloys (sp. gr. 9·54), he found 77·9 per cent of lead and 21·88 of antimony; in the other (sp. gr. 10·08) 82·8 of lead, and 17·2 of antimony).

**Manufacture of Sulphuric Acid.**—A patent has been taken out by A. Mac-Dougal and H. Rawson(1) for obtaining sulphur by the decomposition of sulphuretted hydrogen passed through red-hot tubes.

**By means of Nitric Acid.**—A. Mac-Dougal and H. Rawson(2) manufacture sulphuric acid according to a patent process, by passing sulphurous acid through a series of Woulfe's bottles, of which the first is filled with nitric acid, and the following two-thirds with water. A pneumatic apparatus draws a stream of sulphurous acid (from an ordinary furnace), together with atmospheric air, through the whole arrangement, and indeed through the different liquids, since in each bottle the conducting tubes are carried below the surface of the liquid. It will be observed that this process is a repetition on the large scale of the well-known experiment of Péligré.

**By means of Clay.**—C. Blondeau(3), induced by the study of the efflorescences produced in the conflagrations of mines, by which amongst other substances sulphurous acid is disengaged, and under the influence of the air and of the clay with which it is in contact, is subsequently converted into sulphuric acid, has endeavoured to take advantage of the artificial production of this acid, under the same circumstances, for practical purposes. He succeeded on a small scale by passing sulphurous acid, atmospheric air, and aqueous vapour, simultaneously, through a porcelain tube containing an argillaceous sand (*sable argileux*) heated to dull redness.

**By means of Pumice-stone.**—R. Laming(4) has taken out a patent for a process mentioned in the preceding Annual Report, Vol. II, p. 291, for the manufacture of sulphuric acid without leaden chambers. According to his direction, the pumice-stone should be prepared by boiling with sulphuric acid, washing with water containing ammonia, mixing with 1 per cent of manganese, and igniting.

**Preparation of Chlorine.**—A. Mac-Dougal and H. Rawson(5) have patented a process for the evolution of chlorine in manufactories by the action of hydrochloric acid upon a chromate. From the chloride of chromium, which is the result of decompo-

(1) Chem. Gaz. 1849, 267.

(2) Ibid.

(3) Compt Rend. XXIX, 405; Dingl. Pol. J. CXV, 210.

(4) Lond. Journ. of Arts, 1848, 342; Dingl. Pol. J. CXIII, 128.

(5) Chem. Gaz. 1849, 288.

sition, it is said that the chromate may be reproduced by treatment with nitric acid and subsequent ignition.

Preparation of chlorine.

Elsner(1) found in a specimen of commercial manganese, which evolved chlorine when treated with sulphuric acid free from hydrochloric acid, 1.75 per cent of chloride of calcium and 1.25 of lime, which induces him to suspect an adulteration with exhausted chloride of lime.

**Soda-Manufacture. Analyses of the Products.**—The subjoined analyses of different products of the soda-manufacture have been conducted by F. Muspratt and J. Danson(2), who have, however, omitted to state the method pursued. They examined: A, soda-salt (calcined soda) for soap-boiling; B, soda for plate-glass; C, crude soda; D, residue after lixiviating the preceding product with water, fresh; E, the same six weeks old; F, Glauber's-salt for A, B and C. —The aqueous extract obtained from the soda-ash which has crumbled down in the air gives, as is well known, on evaporation, a colourless crystalline mass, which, when heated, evolves much sulphurous acid and deposits sulphur; hence we are rather surprised that in E hyposulphurous acid is not mentioned.

Constituents.	A.	B.	C	D.	E.	F.
Carbonate of soda . . .	77.08	78.55	28.89	—	—	—
Sulphate „ . . .	5.11	1.70	0.82	—	—	95.94
Silicate „ . . .	2.40	0.25	—	—	—	—
Hydrate „ . . .	4.88	4.15	8.27	—	—	—
Sulphide of sodium . . .	0.63	—	0.40	1.44	2.87	—
Chloride „ . . .	7.13	5.62	3.07	—	—	—
Carbonate of potassa . . .	0.20	—	—	—	—	—
Sulphate of lime . . .	—	—	—	2.53	4.59	0.57
Carbonate „ . . .	0.32	0.33	14.22	41.20	23.42	—
Hydrate „ . . .	—	—	9.24	8.72	12.03	—
Protosulphide of calcium . . .	0.20	—	25.86	25.79	36.70	—
Bisulphide „ . . .	—	—	—	5.97	0.62	—
Sulphate of magnesia . . .	—	—	—	—	—	0.14
Silicate „ . . .	—	—	2.03	3.63	1.78	—
Sesquioxide of iron . . .	0.32	0.27	—	—	—	0.29
Sesquichloride „ . . .	—	—	—	—	—	1.36
Earthy phosphates, sesquioxide of iron and alumina . . .	—	—	6.23	8.91	7.40	—
Water . . . . .	1.06	8.65	0.99	1.73	10.59	1.31
Free acid . . . . .	—	—	—	—	—	
Charcoal . . . . .	0.66	0.48	—	—	—	0.40
Sand. . . . .						
Total . . . . .	99.99	100.00	100.02	99.92	100.00	100.01

(1) From the Berl. Gew., Industr. u. Handelsblatt, in Dingl. Pol. J. CXII, 461.

(2) Chem. Soc. Qu. J. II, 216.

Salts.  
Manufacture of  
Glauber's  
salt.

**Salts. Manufacture of Glauber's-salt.**—E. Thomas, Dellisse and Boucard(1) have communicated a process for converting the common salt into Glauber's-salt by means of iron pyrites. They distil off  $\frac{2}{3}$  of the sulphur from the pyrites, and allow the residuc to remain exposed to the air in heaps, when it crumbles down very rapidly. By lixiviating the mass with water, they then obtain a solution of green vitriol of  $23^{\circ}$  B., which is heated by steam to  $15^{\circ}$ , and mixed, in reservoirs of brickwork, at a freezing-temperature, with a solution of salt of  $25^{\circ}$  B., containing somewhat more than the quantity of salt equivalent to the sulphate of protoxide of iron. The crude Glauber's-salt which then crystallises out, is separated from the mother-liquid, and dissolved in  $\frac{1}{3}$  of its weight of water, freed from iron by mixing with 1 to 2 per cent of milk of lime at  $32^{\circ}$ , filtered through a vacuum-filter, and evaporated. They have calculated that this process effects a saving of  $\frac{1}{3}$  of the ordinary cost of the Glauber's-salt made from sea-salt and sulphuric acid.

**Extraction of Common Salt.**—A. Arrott(2) has taken out a patent for a new method of obtaining common salt from brines. This process is an application of the observation (first made by Fuchs) that a boiling saturated solution of common salt containing chloride of calcium or of magnesium, deposits crystals of common salt on cooling. According to this patent, the liquors are mixed, for this purpose, with a sufficient quantity of either of these chlorides. This artificial difficulty introduced into the process of manufacturing salt is not likely to meet with much approbation in practice.

As a sequel to the analysis of the water of the Mediterranean, communicated in the Annual Report for 1848 and 1849, II p. 256, and with especial reference to the extraction of sea-salt from this water, J. Usiglio(3) has subjected it to a methodical concentration under conditions similar to those which obtain in the salt-ponds (salt-gardens) on a large scale, and has examined the products at different periods of the process. The original sea-water had a density corresponding to  $3.5^{\circ}$  B.; in the subjoined table, the weight and composition of the precipitates and crystalline deposits are given, and correspond to the densities in column 1.

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(1) *Technologiste*, 1849, 347; *Dingl. Pol. J.* CXII, 208; *Instit.* 1849, 43; *Compt. Rend.* XXVIII, 188.

(2) *Lond. Journ. of Arts*, 1849, 105; *Dingl. Pol. J.* CXII, 112.

(3) *Ann. Ch. Phys.* [3] XXVII, 172.





Extraction of common salt.

after each crystallisation. If this precaution be adopted, and the water, when reduced to a concentration of  $35^{\circ}$  B., exposed in thin layers to the air, the following crystallisations are successively observed. In the first night, an abundant separation of nearly pure sulphate of magnesia takes place; the *first mother-liquor* then furnishes, after farther concentration on the following day, a mixture of chloride of sodium, sulphate of magnesia, and, sometimes, chloride of potassium; the *second mother-liquor* separated from these crystals, when cooled during the night, again deposits tolerably pure sulphate of magnesia; the *third mother-liquor* of  $33^{\circ}$  to  $34^{\circ}$  B. ( $=1.308$  to  $1.320$  sp. gr.) gives, after farther concentration during the following day, a very heterogeneous crystallisation of sulphate of magnesia, chloride of sodium, chloride and bromide of magnesium and sulphate of magnesia-potassa (for which Usiglio determined the formula  $2\text{SO}_3, \text{MgO}, \text{KO} + 6\text{HO}$ ). The *fourth mother-liquor* separated from these crystals, as it cools in the evening, and during the night, furnishes a new double salt, which, according to Usiglio, possesses the formula  $\text{Cl}_3\text{Mg}_2\text{K} + 12\text{HO}$ , and which is often mixed with the first double salt. The *fifth mother-liquor* does not crystallise during the ensuing forenoon, when it attains a density of  $37^{\circ}$  B. ( $=1.359$  sp. gr.); at noon, however, the above-mentioned double chloride appears, and continues to deposit during the night, but if the fall of temperature be too rapid or too considerable, it is accompanied by sulphate of magnesia. The liquid (the *last mother-liquor*) has now attained a concentration of  $38^{\circ}$  B. ( $=1.372$  sp. gr.), and has deposited the greater part of its salts; it still contains, however, some chloride of sodium and sulphate of magnesia, with much chloride of magnesium, which last crystallises out abundantly in the autumn, at a temperature of  $+5^{\circ}$  or  $6^{\circ}$ .

**Sulphate of Ammonia.**—R. Smith(1) has proposed the employment of sulphate of ammonia to render wood incombustible, especially for ship-building. He found that this salt was decomposed at  $280^{\circ}$ , evolving ammonia; the sulphuric acid remained, in great measure, in the wood, but part of it was decomposed by the ammonia, with evolution of nitrogen and sulphurous acid. Smith prefers this salt because it renders both the wood and the surrounding atmosphere unfit for combustion.

**Manufacture of White Lead.**—T. Richardson(2) has taken out a patent for a modification of the Dutch process for making white lead. He introduces the finely-granulated lead, moistened with 1 to 1.5 per cent of vinegar, into the compartments of a wooden chest, (heated from the bottom by steam to about  $35^{\circ}$ ), through which he passes a stream of carbonic acid, and sufficient steam to maintain

(1) Phil. Mag. [3] XXXIV, 116; Dingl. Pol. J. CXI, 382.

(2) Lond. Journ. of Arts, 1849, 193; Dingl. Pol. J. CXII, 204.

both the atmosphere in the interior, and the lead, in a pretty moist state. After ten or fourteen days the conversion is complete. The crude white lead is washed as usual, and sent into the market.

—Hugh Lee Pattinson(1) has taken out a patent for the manufacture of basic chloride of lead as a substitute for white lead. He mixes a hot solution of chloride of lead containing about  $12\frac{1}{2}$  oz. in a cubic foot, with an equal volume of saturated lime-water. A precipitate of basic chloride of lead is thus obtained, which is separated from the clear liquid (a weak solution of chloride of calcium), washed and dried. Since 1 c. ft. of saturated lime-water contains  $1\frac{1}{8}$  oz. of lime, the two substances act upon each other in the proportion of  $\text{CaO} : 2 \text{PbCl}$ . Pattinson hence infers that, in this process, the lime (or its equivalent of potassa, soda, ammonia, or baryta), in every case, precipitates the definite compound  $\text{PbCl} + \text{PbO}$ ,  $\text{HO}$ , which has a lustrous white colour, and a good body.

**Burning of Gypsum.**—Violette(2) has extended the principle of heating by steam, applied by him in the carbonisation of wood (Annual Report for 1847 and 1848, Vol. II, p. 356), to the burning of gypsum. The gypsum obtained by his process was whiter than that obtained by the ordinary mode of burning, and of equally good quality; according to Violette's experiments, however, six hours are requisite to bring the gypsum into the state in which it is required for casting. A cubic meter (=1300 kilogrms.) of gypsum required 520 kilogrms. of steam, to which it is most convenient to give a tension of  $\frac{1}{2}$  an atmosphere.

**Hydraulic Lime.**—A. Hopfgartner(3), under Pettenkofer's direction, has examined two specimens of hydraulic cement. A is the English Portland cement, a gray sandy powder with a shade of green; its sp. gr. is 3.050; it hardens in a very short time under water, and this change takes place simultaneously throughout the mass. B is a specimen of marl from the vicinity of Tegernsee; a light, mealy powder of sp. gr. 2.723; gradually hardens, often scales off in large masses, and after hardening remains friable for a long time in the interior. The results of the analyses are given in the table at p. 454. From these analyses Pettenkofer infers that the essential condition for the setting of these cements is to be looked for, not so much in the quantity of the clayey portion (insoluble in dilute hydrochloric acid), as in its composition, which varies considerably in different specimens. He states, moreover, that the properties of a cement not only depend upon its composition and behaviour under the influence of fire and water, but that the volume

(1) Chem. Gaz. 1849, 366; Repert. Pat. Invent. 1849, 150; Dingl. Pol. J. CXIV, 126.

(2) Technologiste, 1849, 411; Instit. 1849, 66; Dingl. Pol. J. CXII, 360.

(3) Dingl. Pol. J. CXIII, 351, 357.

Hydraulic  
lime.

which a given weight of the powdered cement occupies, has likewise an influence upon its hardening. With regard to this point, he found that the same vessel, under similar circumstances, contained 31·8 parts by weight of Portland cement, and only 17·5 of the Bavarian specimen in the form of powder (in both cases rubbed through the same sieve). The particles of the powdered Portland cement appeared under the microscope in the form of scales, and, therefore, arranged themselves more compactly than the granular powder of the Bavarian cement. It will be observed that the above numbers stand in a very different ratio from that of the specific gravities. The Portland cement absorbed only 0·65 per cent (carbonic acid and water) in the same time in which the Bavarian cement increased by 4·47 per cent.

**santorine.**—L. Elsner(1) has analysed the stone called *santorine*, obtained from one of the Grecian islands of the same name, and largely used for marine buildings on the coast of Dahnatia; the results of his analysis are given under C. The santorine is similar in external appearance to the tarras of volcanic origin, but differs from it in being decomposed with greater difficulty by acids, and in losing, when exposed to the air, the hardness which it has acquired under water.

	A.	B.	C.
Lime . . . . .	54·11	52·11	2·36
Magnesia . . . . .	0·75	3·05	—
Potassa . . . . .	1·10	1·00	3·13
Soda . . . . .	1·66	0·25	4·71
Alumina . . . . .	7·75	3·38	13·31
Sesquioxide of iron (with traces of } binoxide of manganese) . . . }	5·30	3·20	5·50
Protoxide of manganese . . . . .	—	—	0·73
Silica . . . . .	22·23	20·82	68·50
Carbonic acid . . . . .	2·15	4·75	—
Phosphoric acid . . . . .	0·75	2·55	—
Sulphuric acid . . . . .	1·00	0·57	—
Undissolved portion (sand) . . .	2·20	1·90	—
Soluble in water . . . . .	—	—	0·31
Water . . . . .	1·00	6·00	1·45
	100·00	99·58	100·00

**Glass fused with Boracic Acid.**—The infusibility of the Bohemian ornamental glass when placed in covered pots in a furnace heated by pit-coal, has up to the present time prevented the introduction of this branch of manufacture into France. Maës(2), however, states that

(1) Verh. Ref. Gew. Pr. 1849, 2. Lief.; Dingl. Pol. J. CXIII, 157.

(2) Compt. Rend. XXIX, 452; Dingl. Pol. J. CXIV, 276.

he has succeeded in obviating this difficulty by the addition of several per cent of boracic acid to the materials (which consist of quartz-sand, lime, and potashes). • The glass thus obtained possesses the requisite lustre, transparency and durability (?). Experiments with the borosilicate of zinc in conjunction with potassa or soda, and of borosilicate of baryta with potassa, have induced Maës to predict the introduction of the former into the glass-manufacture.

Glass  
fused with  
boracic  
acid.

**English Plate-glass.**—J. E. Mayer and J. S. Brazier(1) have analysed three specimens of English plate-glass which were obtained: A from the British Plate-glass Company at St. Helens; B, from the London Thames Plate-glass Company at Blackwall; C, from the London and Manchester Plate-glass Company at St. Helen's. Water dissolved only traces of the finely divided samples after 24 hours digestion. The analyses (in which the alkalies were estimated by means of hydrofluoric acid) gave in 100 parts:

Sp. gr.	A.	B.	C.
	2.319	2.242	2.408
Silica	77.36	78.68	77.91
Potassa	3.01	1.35	1.72
Soda	13.06	11.63	12.36
Lime	5.31	6.10	4.85
Manganese	—	—	trace
Sesquioxide of iron	0.92	trace	—
Alumina	trace	2.68	3.60
	99.66	100.44	100.44

From these numbers they have calculated for A and C the formula  $3 \text{ RO}, 9 \text{ SiO}_3$ , and for B,  $3 \text{ RO}, 8 \text{ SiO}_3$ , wherein the potassa, alumina and sesquioxide of iron are disregarded. If these latter, however, be taken into consideration, the three specimens appear to be mixtures of  $2 \text{ RO}, 5 \text{ SiO}_3$  with variable quantities of  $\text{R}_2\text{O}_3, 3 \text{ SiO}_3$ .

**Devitrification.**—E. Splitgerber(2) has communicated a series of observations upon the phenomenon of devitrification. According to his experiments devitrification takes place most readily in glasses containing much lime and alumina (probably in all the less easily fusible kinds), and is more frequently observed in soda- than in potassa-glasses. He recognises two different modifications of the process, a crystalline and an amorphous devitrification, both of which may sometimes be observed to take place simultaneously. In this process the density of the glass always suffers an alteration; in one

(1) Chem. Soc. Qu. J. II, 208; Edinb. New Phil. J. 1849, 316; Dingl. Pol. J. CXV, 206.

(2) Pogg. Ann. LXXVI, 566; J. Pr. Chem. XLVIII 82; Dingl. Pol. J. CXIII, 28; Berl. Acad. Ber. 1849, 53; Instit. 1849, 254.

Devitrifi-  
cation.

case of amorphous devitrification the density diminished (from 2·571 to 2·562), and in another of compound devitrification it increased (from 2·485 to 2·503). It did not escape Splitgerber that the specimens which suffered devitrification by exposure to heat, at the same time diminished in weight in consequence of the volatilisation of a portion of the alkali. In soda-glasses this loss is more considerable than in potassa-glasses, but even then amounts only to a fraction per cent, on which account Splitgerber does not look upon it as a cause of the devitrification. During the fusion of the ingredients of the glass this volatilisation is very considerable; in three of Splitgerber's experiments, which possess great practical interest, it amounted respectively to 13 per cent and 24 per cent of the soda added, and to 11 per cent of the potassa.

**Silvering Glass.**—T. Drayton(1) has substituted the following process for that which he formerly proposed(2) for silvering glass (by means of essential oils). A mixture is prepared of 1 part solution of ammonia, 2 parts nitrate of silver, 3 parts water and 3 of alcohol; this solution is filtered, and mixed with  $\frac{1}{4}$  part of grape-sugar (dissolved in weak spirit). At about 70° this liquid deposits upon the surface of glass a mirror of silver (which, however, it is difficult to obtain faultless when deposited upon large surfaces).

**Glass-painting.**—G. Bontemps(3) has investigated the effect of the temperature at which the metallic oxide is applied, upon the colour which it communicates to glass. From his observations, passing over much that was already known, we select the following. *Iron*, which generally imparts to glass only a red or green colour, often produces in window-glass a bluish, and in bottle-glass, on cooling, a dark blue shade. If glass coloured with *manganese* remain too long in the melting-pot or in the muffle, the violet colour passes into a clear red-brown, then into yellow, and finally into green. White glass fused with some binoxide of manganese became yellow when exposed to light, whilst a fragment of the same glass remained white when protected from light. Window-glass containing manganese, allowed to remain in the annealing furnace till devitrification had commenced, became semi-translucent and whitish in the interior, being violet only externally. *Copper* ruby-glass, when exposed to a high temperature, passes from carmine to purple, and afterwards to blue, finally becoming colourless. Glass coloured yellow with *silver* became opalescent at a higher temperature, and afterwards yellowish-brown, with a farther loss of transparency. Bontemps thinks that the change of colour which *gold* ruby-glass suffers at a high tempera-

(1) Lond. Journ. of Arts, 1849, 414; Dingl. Pol. J. CXIII, 212.

(2) Dingl. Pol. J. XCIII, 137.

(3) Phil. Mag. [3] XXXV, 439; Chem. Gaz. 1849, 406; Instit. 1849, 382; J. Pr. Chem. XLIX, 175; Dingl. Pol. J. CXIV, 394.

ture, may be ascribed to the presence of silver. He found that *carbon* possessed the property of colouring glass yellow, or by repeated heating, dark red.

**Porcelain.**—W. Wilson(1) found in Berlin porcelain (piece of an evaporating dish) 71·34 per cent of silica, 23·76 of alumina, 1·74 sesquioxide of iron, 0·57 lime, 0·19 magnesia, and 2·00 of potassa.

It frequently happens that in consequence of mismanagement in the firing, the porcelain comes out of the furnace with a sooty-brown instead of a white colour. This colour, which Ebelmen and Bon-temps attribute to the carbon (a sooty flame), is ascribed by Arnoux(2) to the sesquioxide of iron.

**Aventurine-glazing.**—A. Wächter(3) gives the following prescription for the preparation of a porcelain-glaze similar to aventurine. 31 parts of kaolin of Halle, 43 of quartz-sand, 14 of gypsum and 12 of broken porcelain are finely ground, intimately mixed, and stirred up with 300 parts of water; to the mixture thus prepared are added, consecutively, solutions containing 19 parts of bichromate of potassa, 47 of sugar of lead, 100 of green vitriol, and sufficient ammonia to precipitate the whole of the iron. After the removal of the potassa- and ammonia-salts by repeated decantation, the glaze is ready for use, and may be applied to the biscuit-ware by the ordinary process of dipping, and burnt in, as usual, in the kiln. When cold the brownish mass exhibits crystalline leaflets of a golden lustre (appearing under the microscope, and by transmitted light, of a transparent green colour), which Wächter believes to be sesquioxide of chromium, or a compound of this oxide with sesquioxide of iron.

**Porcelain-painting.**—Platinum gives, according to Salvétat(4), by far the best gray colour to porcelain, and has been employed for this purpose in Sèvres since 1848.—Palladium and ruthenium produce a reddish-gray colour; the gray imparted by iridium is far less pleasing and more expensive than that so easily obtained with platinum. The oxides of cobalt and of iron, either with or without manganese, impart, as is well known, a black, or if a large amount of flux be added, a gray colour; however, on account of the variability of the blue and red which form the foundation in these cases, the intensity of the gray shade can only be predicted after very long experience. The gray of platinum, therefore, is preferable on account of the greater certainty with which it may be produced. According to Salvétat, 1 part of powdered platinum-sponge (from the ammonio-chloride of platinum) should be mixed with 3 parts of flux (consisting of 3 parts minium, 1 part sand, and  $\frac{1}{2}$  part fused borax).

Porce-  
lain.

(1) Chem. Soc. Qu. J. II, 154.

(2) Instit. 1849, 408.

(3) Ann. Ch. Pharm. LXX, 57; Dingl. Pol. J. CXIII, 213.

(4) Ann. Ch. Phys. [3] XXV, 342; J. Pr. Chem. XLVII, 232; Dingl. Pol. J. CXII, 113.

Enamel-colours.

**Enamel-colours.**—L. Bohlen(1) has communicated his observations upon the preparation of enamel-colours. For obtaining the *gold-purple* the following prescription appears to him to merit a decided preference: metallic tin is dissolved to saturation in a mixture of 4 parts of pure nitric acid (sp. gr. 1.24), 1 part of pure hydrochloric acid, and  $\frac{1}{2}$  part of spirit of wine (of 80 per cent), which is kept cool during the solution of the tin. The decanted liquid is diluted with 80 times its weight of distilled water, and precipitated with a solution of gold in *aqua regia* from which the free acid has been expelled as far as possible. The precipitate thus obtained has a purple-red colour both when moist and dry.—Bohlen, moreover, prefers preparing the purple intended for rose-red, not by means of carbonate of oxide of silver, but with silver-leaf finely triturated (with honey); in both cases he employs as a flux a mixture of 6 parts of minium, 2 of silica, and 5 of fused borax. For *chrome-green*, Bohlen recommends, in spite of the cost, the preparation of sesquioxide of chromium from the chromate of suboxide of mercury, and ignition of the product (with or without oxide of cobalt for several hours) till it has attained the desired colour. For *cobalt-blue*, Bohlen proposes a new method of preparing oxide of cobalt, which is applicable to technical purposes generally, although it does not furnish an uniformly pure product. He roasts the powdered (Saxon, Thuringian, or Tunaberg) cobalt-glance with  $\frac{1}{3}$  of charcoal powder, as long as arsenical fumes are disengaged (a very long operation), and boils the product twice or thrice in a mixture of 4 parts of nitric acid, 1 of hydrochloric acid and 15 of water. He then evaporates the diluted and filtered solution to dryness, when arseniate of sesquioxide of iron is deposited, and must be separated by redissolving and filtering; to the green solution (containing cobalt, iron, nickel, and manganese) carbonate of potassa is added until the precipitate, at first of a dingy red colour, begins to assume a blue shade, a point requiring particular attention to avoid a loss of cobalt. This precipitate is separated by a third filtration, and the cobalt is then completely precipitated from the fine red liquid by a farther addition of carbonate of potassa. The washed and dried precipitate is ignited for two hours in a Hessian crucible placed in a blast-furnace, together with 1 part of silica and  $1\frac{1}{2}$  parts of oxide of zinc, and the finely-divided frit afterwards mixed with an equal weight of lead-glass as a flux.—Lastly, Bohlen recommends the following enamel as a substitute for *uranium-yellow* when no pitch-blende can be obtained: 12 parts of white oxide of antimony, 6 of oxide of zinc, 8 of fused borax, 12 of silica,  $1\frac{1}{2}$  of dry carbonate of soda, and 1 of hydrated sesquioxide of iron are fused with 96 parts of minium for glass-painting, and with 48 parts for porcelain-painting.

Salvétat(1) has inquired into the circumstances which regulate the success and beauty of the enamel-colours prepared with sesquioxide of iron, which, it is well known, pass from orange into violet, and even into gray. For this purpose he has analysed a series of these colours, which are in the highest repute, furnished to him by Pannetier; the percentage results are as follows (the colours are distinguished by the designations in ordinary use at Sèvres):

	Silica.	Oxide of lead.	Borax.	Sesquioxide of iron.	Oxide of zinc.	Alumina.	Binoxide of manganese.
Rouge orangé . . .	17.48	51.54	13.08	14.10	3.80	trace	—
„ capucine . . .	16.60	50.39	12.51	20.50	—	trace	—
„ sanguin . . .	16.90	49.51	13.39	19.70	—	0.5	—
„ de chair . . .	16.60	49.18	14.22	20.00	—	trace	—
„ carminé . . .	16.30	50.02	13.68	20.00	—	trace	—
„ laqueux . . .	16.40	49.44	15.96	18.20	—	trace	—
„ violâtre pâle . .	16.85	50.66	12.66	19.83	—	trace	—
„ „ . . .	16.39	50.52	12.01	21.08	—	trace	—
„ „ foncé . . .	16.56	50.09	15.36	17.99 *	—	trace	—
„ „ très foncé . .	16.40	50.60	12.14	18.71	—	trace	2.15
Gris de fer . . .	17.09	47.30	17.01	18.60 *	—	trace	—

\* Including the binoxide of manganese.

From these results Salvétat has deduced several important practical conclusions. He has established the fact that the sesquioxide of iron alone is capable of producing any shade between *rouge capucine* and *rouge violâtre*, and that every difference of tint depends upon the temperature to which the oxide is raised in its preparation; after a moderate ignition it gives a red colour passing into yellow, but when strongly ignited, this red changes to blue; the purity of the tint is perfect only when every particle of the oxide is exposed to the same degree of heat, since those particles which have been less strongly ignited produce an admixture of yellow, and those which have been subjected to a very high temperature impart a violet shade. The shades beyond the two limits can only be produced by additions of certain substances to the sesquioxide of iron. For *rouge orangé*, according to the analysis, and to various synthetical experiments, oxide of zinc must be added, which is supposed by Salvétat to replace the water of hydration; to impart the various shades from violet, downwards manganese is employed, upon the *modus operandi* of which farther information is promised. Lastly, Salvétat ascertained by various experiments that pure sesquioxide of iron, and that which had been mixed with (even  $\frac{1}{2}$  of) alumina gave exactly

(1) Ann. Ch. Phys. [3] XXVII, 333; J. Pr. Chem. XLIX, 210; Ann. Ch. Pharm. LXXII, 114 (in abstr.)



Enamel-  
colours.

similar shades, showing that the admixture of alumina is without effect.—Salvétat has calculated from the above analyses the proportion in which the flux stands to the colouring oxide, *i. e.* to alumina and sesquioxide of iron, binoxide of manganese, or oxide of zinc, and finds that 1 part of the colouring material is employed for 4 parts of a flux consisting of 1 part silica, 3 parts oxide of lead, and  $\frac{3}{4}$  part borax. The colours of Pannetier, therefore, contain more flux, and this of a more easily fusible description, than the colours obtained from other sources, since in the latter the proportion is 1 part of colouring oxide to 3 parts of a flux consisting of 1 part silica, 3 parts oxide of lead, and  $\frac{1}{2}$  part borax.

**"Tinted" Porcelain-Colours.**—Salvétat(1) has found it advantageous to mix the red of safflower with the pigments used in porcelain-painting for purple, carmine, and violet, colours which, in consequence of the difference of their shade before and after firing, are very liable to mislead. To avoid this, he imparts to the pigment (consisting of flux, gold-purple, and chloride of silver), by means of safflower suspended in water, the same shade which he desires to obtain after firing.

**Agricultural Chemistry. Cultivation of the Vine.**—J. Per-soz(2) has made some experiments upon the cultivation of the vine, which show that in the early period of its growth, attention must be paid chiefly to the development of the wood(3), and at a more advanced stage, to that of the fruit. In order to promote the former, he finds a dressing with ground bones, gypsum, and horn- or leather-cuttings very serviceable, and for the latter he recommends the application of soluble potassa-glass, and of phosphate of lime-potassa, giving at the same time more precise directions for the application of these fertilizers.—The phosphate of lime-potassa is prepared by decomposing bone-ashes with sulphuric acid, decanting, saturating the solution of acid phosphate of lime with potashes, evaporation, and ignition to a dull red heat.

**Manuring Land with Limestone.**—N. Boubée(4) has observed some very favourable results produced by spreading coarsely pulverised limestone upon a field consisting of granitic soil.

(1) Ann. Ch. Phys. [3] XXV, 341; Dingl. Pol. J. CXII, 47; J. Pr. Chem XLVI, 478; J. Pharm. [3] XV, 273.

(2) From his treatise, "Nouveau Procédé pour la Culture de la Vigne," in J. Pharm. [3] XV, 196, 295; Dingl. Pol. J. CXII, 443; see Annual Report for 1847 and 1848, II, 316.

(3) In the juice of the young twigs of the vine, bitartrate of potassa is present in abundance, and crystallises out on evaporation.

(4) Compt. Rend. XXIX, 401.





**Manuring Land with Gypsum.**—For agricultural districts in which the application of natural gypsum is too expensive, Lebrun(1) proposes to use as a substitute a mixture of disintegrated lime with  $\frac{1}{10}$  of its weight of flowers of sulphur, which under the influence of atmospheric air and moisture, is said to be converted into sulphate of lime. —Lassaigue(2), however, states that the action of the air is exceedingly slow, and is limited to the formation of a small quantity of hyposulphite of lime.

Manuring  
land with  
gypsum.

Caillat(3) has published the results he has obtained in determining the proportion of sulphur in clover and lucerne by the method mentioned at p. 418. He has thus arrived at the following facts: 1. that the same plants under similar circumstances contain more sulphate of lime after being manured with gypsum than they do when this manure is not employed; 2. that a large quantity of gypsum enters as such into the composition of the plants, a fact which, however, by no means excludes the possibility of its action in the manner pointed out by Boussingault and Liebig; 3. that the gypsum which is absorbed by plants passes chiefly into the parts which still retain their viridity.

**Guano.**—Th. Way(4) has published a comprehensive investigation regarding guano. The author has chiefly two objects in view: he hopes 1st, to afford a farther contribution to our knowledge regarding the composition of this manure; and 2nd, to establish the money-value of the various kinds occurring in commerce. Way carefully selected authentic specimens, which were supposed to represent the average properties and composition of each kind. For the first of the above-mentioned purposes he subjected to complete analysis a series of specimens of Peruvian guano which is considered to be the most valuable, and a similar series of Saldanha-Bay guano of inferior quality. (No. 1 to No. 12, Table H). They need no farther remarks.

According to Way, the agricultural value of the various kinds of guano consists of three factors. First the quantity of *ammonia* which a given kind evolves during its decomposition in the soil; this is indicated by the amount yielded on combustion with soda-lime. The second factor is the proportion of *phosphoric acid*, and the third that of the *alkalies*. With this conception of the question, Way has adduced nearly 100 analyses of guano of different sorts, part of which were made by himself, some by Ure, and others by Teschemacher. Collectively they prove that the various kinds occurring

(1) J. Chim. Méd. [3] V, 367; from the Moniteur Industr., in Dingl. Pol. J. CXII, 399.

(2) Instit. 1849, 234; J. Chim. Méd. [3] V, 473; from the Moniteur Industr., in Dingl. Pol. J. CXIII, 392.

(3) Loc. cit. p. 418.

(4) Journ. of the Royal Agricult. Soc. of England, X, Part 1.

Guano.

in commerce vary in the greatest degree in their quantities of ammonia. In point of value the Angamos guano, a Peruvian variety, of recent origin, which has hitherto been met with only in very small quantities, ranks first; next to this the common Peruvian, the Ichaboe, the Patagonian and the Saldanha-Bay guano follow in decreasing value.—In the second half of his memoir, Way has given a calculation of the money-value of the different kinds of guano in comparison with that of other manures.

Regarding the presence of phosphates in guano, see *Stercorite* in the Report on Mineralogy.

**Various Kinds of Manure.**—In another memoir, Way(1) has investigated various materials which are used in agriculture as manure, and likewise such as have been recommended as fertilising agents.

1. *Sprats* (Germ., *Sprossen*; French, *Esprots*; Ital., *Sardino*; a small species of herring, *Clupea sprattus*), which are caught in enormous quantities on the coasts of Sussex, Kent, and Essex, and are used as manure for wheat and hops. A sufficient number of the fish were crushed, and the mass dried and investigated. It yielded 64 per cent of water, 19 per cent of fat, and 1.94 per cent of nitrogen, corresponding to 16.8 per cent of albuminous compounds. The composition of the ash is given in Tab. F. Nos. 205 and 206.

2. *Liquid manure*, from a tank which communicated only with the cow-houses and piggeries. One litre yielded 17.23 grms. of solid constituents, which consisted of 11.56 grms. of ash, and 5.67 grms. of organic matter; 1 litre, moreover, yielded 5.08 grms. of ammonia. The analysis of the ash is given under No. 207 of Table F.

3. *Scutch*, consisting of hair and other animal matters with lime. Regarding the composition, See Nos. 13 and 14, Tab. H. The specimen, No. 13, gave 0.89, and No. 14, 1.57 per cent of nitrogen.

4. *Old alkali waste*, No. 15, Tab. H., which may be employed as a mixture of gypsum and carbonate of lime.

5. Three kinds of *woollen refuse*, which is known to be a very efficacious manure, gave 7.87, 7.00, and 8.70 per cent of water, and when dried, 11.37, 10.67, and 12.97 nitrogen.—The composition of a fourth kind, of inferior quality, is given under No. 16, Tab. H.

6. The compositions sold under the name of "*animal guano*," (Nos. 17 and 18, Tab. H.), and those under Nos. 19, 20, and 21, are valueless as artificial manures. No. 22, sold under the name of "*tillage for turnips*," is nothing but a red soil, probably derived from the new red sandstone formation(2).

(1) Journ. of the Royal Agricult. Soc. of England, X, Part 2.

(2) The patent specification of Th. Richardson's artificial manure, see Chem. Gaz. 1849, 28; Dingl. Pol. J. CXI, 310.—In reference to the ash of human excrements, see p. 385. Regarding the proportion of alkalies and phosphoric acid, as well as the composition of coprolites, see the Report on Chemical Geology.

J. Durocher(1) has published some observations, regarding the influence of the soil upon vegetation. His paper, however, contains nothing that is new.

Various  
kinds of  
manure.

**Russian Black Earth.**—E. Schmid(2) has repeated the analysis of Russian black earth (*Tscherno-sem*) with four specimens from the district Orel. Nos. 1, 2 and 3, are virgin soils from three different strata. No. 4 came from an unmanured arable field. The specimens appeared of a dark grayish-brown colour, and formed a fine powder perfectly free from gritty particles. Schmid determined the organic substance by the loss which the earth suffered on ignition, and treated the ignited residue with concentrated hydrochloric acid; the insoluble portion is termed "silica and silicates." In addition to the results which are given in Tab. A, Nos. 19 to 22, the percentage of nitrogen in the dried earth, and the specific gravity have likewise been determined.

	1.	2.	3.	4.
Nitrogen . . .	0.99	0.45	0.33	0.48
Sp. gr. . . . .	2.21	2.28	2.21	2.10

The residue of No. 3, which was insoluble in hydrochloric acid, yielded: 84.21 per cent of silicic acid, 12.43 sesquioxide of iron and alumina, 1.21 lime, 0.37 magnesia, 1.17 potassa, and 0.32 soda.—Each of the specimens, when treated with water, yielded a yellowish-coloured extract, which could not be obtained clear even by passing it through a double filter; the portion soluble in water therefore could not be determined with certainty; it was, however, less than one per cent. The microscopic examination led to no definite result.—Schmid considers the extraordinary fertility of the black earth to be chiefly due to humus, to which he attributes less of a chemical action than of a mechanical effect in loosening the soil.

**Investigations of the Ashes of Plants.**—The most recent scientific researches regarding the mineral constituents of vegetables are characterised by a three-fold tendency; firstly, by a severe criticism of the methods employed; secondly, by entering into the study of the distribution of the constituents of the soil in the various organs of plants; and finally, by a more statistical mode of treatment(3).

(1) Compt. Rend. XXIX, 746.

(2) Petersb. Acad. Bull. VIII, 161; J. Pr. Chem. XLIX, 129.

(3) Our knowledge regarding the occurrence of mineral substances in the organisms of plants, and the necessity of these constituents to their existence, and development, is, like the commencement of all knowledge, only of a qualitative character. The constant occurrence of phosphates in the seeds of plants proves almost beyond a doubt the necessity of the presence of these salts in their formation; in like manner, the presence of alkalis, which we find in the form of carbonates in the ashes of ligneous plants, or

Relations  
between  
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and the  
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**Relations between the Constituents of Vegetable Ashes, and the Development of Plants.**—The Prince of Salm-Horstmar(1) has been engaged in a series of synthetic experiments, in order to decide which of the ash-constituents are absolutely necessary to the growth of plants, and which are not. He chose for his experiments the oat-plant, sowed the grains in an artificial soil of ignited sugar-charcoal, watered it with distilled water, and supplied the ash-constituents by means of the following preparations, which were partly dissolved in the water, and partly incorporated in the sugar-charcoal: silicate of potassa and of soda; carbonate, phosphate, and sulphate of lime; the same salts of magnesia; sesquioxide of iron containing protoxide with and without manganese; sulphate of protoxide of iron; carbonate of manganese; carbonate of ammonia; nitrate of lime, magnesia, and ammonia. By modifying the experiments in various ways, omitting one, and sometimes all of these preparations—adding them at one time in increasing proportions, and at the other times in decreasing quantities, and in each instance accurately observing the growth, appearance, and character of the plants thus cultivated, Salm-Horstmar arrived at the following results: without addition of any of the above-mentioned substances the plants remain dwarfish, but without any abnormal development. For the successful growth of plants, nitrogen (ammonia) and the requisite ash-constituents must be added at the same time. Absence of the one, especially of the latter, enfeebls the action of the other. In the absence of phosphoric acid, sulphuric acid, potassa, lime, iron and manganese, the plants, in every instance, attained an abnormal growth, were feeble, and of unnatural softness, and rapidly faded away; they were particularly weak when no silicic acid and magnesia were present. Iron acted most surprisingly upon the luxurious and vigorous appearance, especially in regard to the colour, strength of stem, and roughness; but when an excess was added it produced dry spots on the plants. Too large a proportion of manganese caused the leaves to curl up in a peculiar manner. Without weakening the plants neither the potassa could be replaced by soda, nor the lime by magnesia.

In the whole of these experiments the plants were placed in abnormal circumstances, and only in one single instance (and in that only a single grain was produced) did they yield corn. Moreover, the experiments were exclusively confined to the constituents, and the quantities required thereof, without any attention being paid to the way in which the nutrition of the plants was accomplished, whilst

such as are rich in sugar, amylon and oil, appears to bear a certain relation to the assumption and deposition of carbon. To discover in what relation the phosphates or the alkalies individually stand to each other in these functions, what part they independently play, is the present problem.

(1) J. Pr. Chem. XLVI, 193 (subsequently, with improvements and additions, J. Pr. Chem. XLVII, 480); J. Pharm. [3] XV, 470.

the influence of the chemical and mechanical condition, the state of combination, the solubility, the division of the individual nutritive substances were likewise entirely disregarded.

Ratio of  
soda to  
the  
potassa in  
wood.

**Ratio of Soda to the Potassa in Wood.**—C. Bischof(1) has made the question, regarding the ratio of soda to the potassa in wood-ashes, the subject of a comprehensive investigation. The author was led to this investigation by the discrepancies exhibited by the composition of the ashes of different kinds of wood, and of the potashes which are prepared from them. Whilst in these ashes, a proportion of soda amounting to from 0.058 to 2.17 times the quantity of potassa is present, Wittstock, Thaulow, and Bley, have found only traces in potashes, but on the other hand, Hermann has found in the potashes from Kasan, as much as 4.16 per cent of soda. Bischof does not attempt a repetition of the analyses of potashes, but rather seeks an answer to the above question by the observation of the following points. 1st, the method of incineration; 2nd, the method of determining the alkalies; 3rd, the locality or nature of the soil; and 4th, the botanical differences of the trees.

After Bischof had convinced himself that the exhausting the wood with boiling sulphuric acid to avoid incineration led to no result, and that the particles carried off with gases during the process of incineration contained, it is true, chlorine, sulphuric acid and lime, but only traces of alkalies, he prepared for his experiments a carbonaceous ash by burning the wood in a chafing-dish, from which the flame was conducted by means of a bent tube covered at the extremity with wire gauze, and destroyed the carbon by igniting the ash in a platinum dish. The method of Rose did not appear to him to be attended with any particular advantage for this purpose.

A comprehensive investigation into the ordinary methods of determining the alkalies(2), and experiments upon the constituents soluble in water, and those which are insoluble, as well as upon the entire ash, led the author to the conclusion that the discrepancies in the proportions of soda found in the ash of the same plants are principally due to the method of analysis. To obtain some information regarding the 3rd point, namely, the influence of locality and nature of the soil, he selected wood of different ages and different seasons, with and without the bark, taken from stems sometimes of 2, sometimes of 4 inches in diameter, of *Quercus robur* and *Fagus sylvatica* of well-chosen localities. These were: the *Siebengebirge* and *Vorgebirge* near Bonn, whose rocks (Labradorite and Albite), with the exception of the Drachenfels, which consists of vitreous felspar, contain a preponderating proportion of soda; the *Rückersberg* near Obercassel,

(1) J. Pr. Chem. XLVII, 193; in part as Dissertation "de Alcalibus in Plantis," Bonn, 1848.

(2) See this Report, p. 418.



Ratio of  
soda to  
the  
potassa in  
wood.

with a preponderating quantity of soda; the aluminous slate district of *Benndorf* near Coblenz, containing only potassa; the *Venusberg* near Bonn, a soil derived from the debris of crystalline and sedimentary rocks. All the specimens of wood were selected from localities where no intermixture of foreign substances was to be apprehended.

From his experiments, made with the object which we have indicated, Bischof has arrived at the following general conclusions:

The soda is present in that portion of the ash which is soluble in water, in quantity too small for determination; this is the case with the oak and with the beech, whether the soil be poor or rich in soda. The proportion of soda also contained in that part of the ash(1) which is insoluble in water, amounts only to a small title of the quantity of potassa present, even in soils containing an excess of soda. The ratio of alkalies in wood is throughout different from that of the corresponding soil: nevertheless, the difference in the composition of the soil has some, but only a minute influence.

**Ratio of the Potassa to the Soda in Plants generally.** — C. Bischof(2) has been induced, from the foregoing results of his investigations on the oak and the beech, to examine for the same object, the proportions of potassa and soda, in the ashes of other plants. For this purpose he has given a synoptical table of the proportions of potassa and soda, expressed in percentage-numbers of the total amount, contained in 215 different ashes of plants. The trustworthiness of the numbers so obtained, or in other words, the knowledge of the ratio of the two alkalies to each other, is essentially dependent on the accuracy and care displayed in conducting the analyses.

Hence he first directs his attention to the method of analysis, and states that the remarks of Heintz, Mitscherlich, Rammelsberg and H. Rose have excited the doubts of chemists regarding the trustworthiness of previous analyses of ashes generally, and especially the determinations of potassa; he, moreover, points out that in the ordinary method of determining the soda from the difference, every impurity of the alkaline chlorides, for instance, the imperfect precipitation of the chloride of barium, presence of phosphoric acid, as well as the indiscriminate use of bichloride of platinum, tends to produce an apparent increase in the quantity of soda; he finally states that an accurate separation of potassa and soda was only in few analyses actually intended, and frequently intentionally omitted.

Amongst the 200 land-plants of the above-mentioned synopsis,  $\frac{1}{5}$  contained potassa only; these included many grains of corn, peas and beans;  $\frac{6}{7}$  contained a considerably larger quantity of potassa than of soda; amongst this number are included most of the other culti-

(1) Comp. p. 418 of this Report.

(2) J. Pr. Chem. XLVII, 208.

vated plants, especially tobacco and sugar-cane, in which the potassa amounted to between 0.75 and 0.96 of the total quantity of alkalis. Bischof here adds some remarks upon the circumstances which may lead to fallacies regarding the relative quantities of potassa and soda.

Ratio of  
the  
potassa to  
the soda  
in plants  
generally.

A comparison of the ash-analyses with the corresponding soils offers a far more important contribution towards the solution of the question at issue, than do the mere analyses of the ashes themselves. However, on account of the very uncertain data regarding the soils, Bischof was unable to institute an inquiry of this kind. A specimen of wheat analysed by Erdmann, and of the horse-chestnut investigated by Wolf, were free from soda, although the plants were grown upon a porphyry soil, containing principally soda-felspar. According to Daubeny, no difference was found between barley grown on the coast and some which was cultivated in the inland districts of England. In cases wherein the soil on which the plants have grown has been analysed, a comparison is inadmissible, since generally no distinction is made between the soluble accessible alkali, and that which is contained in the non-disintegrated constituents of the soil. Way alone has analysed the extract of the soil obtained by water holding carbonic acid in solution. With only one exception he found it to contain soda as the prevailing constituent, whilst in the crops produced on the same soil, he found potassa to prevail.

In like manner, marine plants, which grow in a medium, containing 20 times more soda than potassa, nevertheless assimilate of the latter a larger quantity than  $\frac{1}{10}$  of the former. Fourteen species of fucus, investigated by Forchhammer(1), contained on the average equal proportions of the two alkalis.

From the preceding facts, which have been very minutely examined by Bischof, the author concludes that an unequivocal preference is given by plants to potassa, and that the two alkalis must be evidently of very different value for the functions of the vegetable organism. He is of opinion that a mutual substitution of these bases for one another cannot be admitted as a general law, but must rather be considered as an exception. He acknowledges, however, that the question regarding the preference given to potassa, cannot be well definitively discussed without taking into consideration at the same time the varying distribution of the soil-constituents in the different organs of plants, and during the different stages of vegetation, &c., points which have not yet received sufficient attention, observation being in fact confined to the orange and the horse-chestnut; he leaves it undecided whether this preference be of a more general or a limited signification. It is rather surprising that

(1) J. Pr. Chem. XXXVI, 385.

The ashes  
of plants  
in their  
relation to  
the ex-  
haustion  
of soils.

Bischof should have omitted to classify the soil-constituents, present in a plant at the time of incineration, into assimilated and non-assimilated (mere accidental) constituents, a classification which is closely connected with the question at issue.

**The Ashes of Plants in their relation to the Exhaustion of Soils.—**

In order to render the analysis of soils of any real utility to agriculture and vegetable physiology, the primary and essential requisite is that the specimen submitted to analysis should represent the mean quality of the soil, the nature of which is to be determined. An experiment undertaken by the Landes-Oeconomic-Collegium (Board of Agriculture), of Prussia, to ascertain the exhaustion of the soil by any given crop(1), furnishes an interesting, though not very satisfactory proof how important it is to pay attention to the above-mentioned conditions. They adopted the following method: before the experiment, the chemical condition of the experimental field was first determined; it was then cultivated successively with the same crops (peas and rape) until it was incapable of yielding any more produce, when, finally, the condition of the exhausted soil was again ascertained by a similar analysis, in order to compare the difference thus obtained in the soil, with the amount of ash of the successive crops. In order, as much as possible to divest the result of all local influences, it was farther resolved that the experiment should embrace soils in 14 different places of the kingdom. Finally, as an accessory to the above condition in the instructions issued for the undertaking, and committed to 14 cultivators, the Board farther required that a field of as nearly uniform a character as possible should be selected; from 10 or 12 different places of this field equal quantities of the arable soil, through its entire depth, should be taken up with the spade, put into a deal barrow, well mixed (with a spade?) and the specimen taken from the mixture. Every sample was entrusted to three different chemists to be analysed; in this manner the 42 results of Table A, Nos. 1-14, were obtained. It is obvious that a specimen so selected cannot possibly be a representative of the medium condition of the soil. This might perhaps be obtained by passing several cubic yards of the soil through a mill, and thus reducing it into an impalpable powder, which would have to be submitted, moreover, to a process of careful lixiviation and sifting. According to the above treatment, the samples must vary from the mean composition of the soil, by their probably containing lumps of earth, and stones; a circumstance of itself sufficient to falsify the result; but there is a more general source of discrepancy, partly in the circumstance of the sand, the earthy and the soluble constituents being incapable of uniform mixture in a barrow, and partly in the mode of collecting them. If the spade only penetrates once or twice the subsoil to the depth of half an inch, this of itself will vitiate

(1) From Ann. der Landwirthschaft, &c., XIV, 2, in J. Pr. Chem. XLVIII, 447.

the result. If the Board of Agriculture, in this praiseworthy undertaking, intended to exemplify in how far agriculture can rely upon the analysis of tillage-soil, and what advantage it can expect from the same, some pains should have been taken to secure to the chemists engaged to control each other, the means of arriving at similar results, by furnishing them with the same materials. In fact, the extraordinary differences in the analyses of the same soils are powerful evidence of the illusions under which the Board has laboured during the collection of the samples. Differences in the determination of silicic acid of from 2 to 3 per cent, as they occur throughout the whole of the analyses, or from 63 to 72 per cent (No. 2), of 78 to 88 per cent (No. 3), of 75 to 84 per cent (No. 14), in the hands of experienced chemists, aided by the present method of analysis, can be solely owing to the mode of collecting the specimens. We cannot be surprised to find that the variation is still more considerable in such constituents as are only sparingly present in the soil. The following is a tabular view of the proportional quantities of phosphoric acid, of soda, and of potassa in the three corresponding analyses, and in round numbers:

The ashes of plants in their relation to the exhaustion of soils.

No. of the soil.*	Phosphoric acid in the			Potassa in the			Soda in the		
	first	second	third	first	second	third	first	second	third
	analysis.			analysis.			analysis.		
1	1	3	7	3	1	0	6	1	0
2	1	19	92	1	12	6	1	19	67
9	trace	114	1	3	1	2	2	2	1
10	1	103	18	trace	0	0.05	trace	0	0.04

\* Corresponding to the numbers of the Table A.

It is obvious that the difficulties of soil-analyses are almost entirely confined to the methods adopted for procuring an average sample. This might, however, be easily procured if the object was merely to ascertain the composition of the soil in general, but this knowledge is of very subordinate value. An analysis cannot further the objects of vegetable physiology and agriculture, unless it affords an insight into the manner both of the distribution of the constituents of the soil, and of the combination of the various constituents into proximate minerals—into the degree of solubility and disintegration, and the mechanical condition of the soil in general. The Prussian Board of Agriculture, indeed, has clearly perceived the importance of these conditions, and points out the interest which is attached to the knowledge of the soil-constituents, which are soluble in carbonic acid water, and has proposed, on account of the easier manipulation in analysis, to replace this solvent by hydrochloric acid. However, in the specimens analysed, the true average ratio of soluble and insoluble matter no longer existed, and the accuracy of the results was moreover

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affected by the limited quantity of soluble constituents, the analysis of which is necessarily attended with many errors of observation. It is not within our province to point out the means of performing the experiments with better results, but every improved method must, as far as possible, establish a surer basis for drawing conclusions from small amounts to large ones—from an ounce of the earth under examination, to two millions of pounds of arable soil in the field. It would, for example, be necessary to remove the soluble constituents from a larger mass of soil, and then to divide them into specimens, instead of dividing the soil into samples of a few grammes, and afterwards extracting the soluble constituents.

In reference to the special problem of the Board, namely, to determine the exhaustion of the soil from the difference of its condition before and after the cropping, it may be said *a priori* that it is impossible, because it implies a demand on chemical analysis which exceeds about a thousand-fold its capabilities. For the 13 lbs. of phosphoric acid which a crop of summer-rape withdrew from an acre of land—as the reporter, Magnus, has very aptly shown—only amounts to 0·00066 per cent of soil.

The procedure of the Board of Agriculture is no isolated case. The greater number of the other analyses of soils which hitherto have been published belong to the same category; but experience of so comprehensive and expensive a nature as the present, permit us to hope that a firmer and more suitable support will in future be secured to the mighty lever of united means and forces.

**Vegetable Ashes. Peas, Rape.**—The analyses from No. 1 to 14, Table A, refer only to the soil before cropping; and for the present only the analyses of the first crop of peas and rape have been made public. They are given in Nos. 1 to 28 inclusive, and in Nos. 117 to 138 inclusive, of the tables B, D and E. This investigation possesses the interest of affording a comparison of the constituents of the ashes of the same organs and plants produced on different soils, conducted more extensively than any similar previous examination. On the whole, however, with the exception of a few points directly to be mentioned, our knowledge of the functions of the constituents of ashes receives no essential increase by these experiments. The influence of the diversity of soil, although perceptible, is undetermined and but slightly marked, the fluctuations in the proportion of individual constituents are not greater than in similar soils, *e. g.*, in the different amounts of potassa and phosphoric acid. A striking anomaly is exhibited by the peas of Jurgaitschen; the peas themselves contain 36 per cent of potassa without any soda; the straw 0·35 per cent of potassa and 21·16 per cent of soda.—The quantity and composition of the ashes of both plants appear throughout less variable in the seeds than in the haulm (the stalks and leaves); the preponderance or the diminution of one of the constituents of the stem-ashes is by no means a criterion for deciding that there



TABLE L.

Numbers corre- sponding to Tabs. B to F.				Water in 100 parts of air-dried	Sulphur in 1000 parts of dried
				Substance.	
61	Red clover hay	{	upon sandy soil . . . . .	13.97	4.099
62			„ clayey soil . . . . .	12.20	5.399
63	White clover „	{	„ sandy soil . . . . .	12.60	3.902
64			„ clayey soil . . . . .	12.00	3.500
65	Trefoil „	{	in flower . . . . .	11.24	0.560
66			with seed . . . . .	12.34	0.630
117	Ital. rye-grass „	{	in flower . . . . .	11.59	0.680
118			with seed . . . . .	13.10	0.401
194	Hop strobiles . .	{	Bentley hops . . . . .	9.91	3.900
195			Golding „ . . . . .	12.33	4.720
196			grape „ . . . . .	9.66	5.200
37	Seed of white peas	{	seed-peas . . . . .	13.60	3.724
38			produce thereof cultivated on clayey soil	15.40	2.792
39	Seed of gray peas (prolific maple)	{	„ „ „ „ sandy soil	13.60	2.499
40			seed-peas . . . . .	14.60	2.493
41		{	produce thereof cultivated on clayey soil	16.60	2.617
42			„ „ „ „ sandy soil	16.40	2.696
49	Heligoland beans, (the beans)	{	seed-beans . . . . .	13.20	4.585
50			produce thereof cultivated on clayey soil	14.20	2.331
51	Mazagan beans (the beans)	{	„ „ „ „ sandy soil	15.80	2.494
52			seed-beans . . . . .	17.00	2.663
53			produce thereof cultivated on clayey soil	11.00	2.563
54			„ „ „ „ sandy soil	16.50	2.959
55	Straw { Heligo- land- of { beans	{	cultivated on clayey soil	11.04	2.710
56			„ „ sandy soil	8.12	2.410
57	Maza- gan- of {	{	„ „ clayey soil	10.81	3.770
58			„ „ sandy soil	9.58	2.005
43	Straw { white of { peas	{	„ „ clayey soil	11.89	4.03
44			„ „ sandy soil	6.34	3.23
45	grey	{	„ „ clayey soil	11.36	3.88
46			„ „ sandy soil	8.66	4.37
33	White peas, (the peas)	{	chalk soil . . . . .	17.50	—
35			loam soil . . . . .	16.00	—
34	(the straw)	{	chalk soil . . . . .	15.64	—
36			loam soil . . . . .	15.38	—
59	Common field- beans. { the beans	{	loam soil . . . . .	10.00	—
60				10.71	—

TABLE K.

Numbers (corresponding to those of the Tables E and F.)	VARIETY.	Relative weight of the root and herblant, (Root = 100.)	Root.			Herblant.		
			Percen- tage of water.	Percentage of ashes		Percen- tage of water.	Percentage of ashes	
				fresh.	dry.		fresh.	dry.
TURNIPS.								
—	Laing's self-preserver	15.7	87.7	0.79	6.40	86.0	1.88	13.4
162	Skirving's swede . . .	11.1	87.9	0.88	7.30	85.8	1.61	11.3
—	Ditto . . . . .	7.5	87.0	0.60	4.60	86.0	2.35	16.8
—	" . . . . .	6.4	88.0	0.81	6.72	84.0	2.64	16.5
—	" . . . . .	6.4	87.0	0.52	4.00	84.0	1.76	11.0
—	" . . . . .	8.7	86.0	0.72	5.12	82.0	1.44	8.0
154	" . . . . .	12.1	87.5	0.75	6.00	88.0	1.97	16.4
156	" . . . . .	16.3	89.0	0.76	6.90	85.0	1.95	13.0
158	Dale's hybrid . . . .	49.3	88.0	1.01	8.11	89.0	1.19	10.8
160	Ditto . . . . .	22.0	92.0	0.73	9.06	86.0	2.25	16.1
161	Green-top white . . .	61.3	92.0	0.59	7.10	88.0	1.82	15.2
—	White globe turnip . .	19.0	87.0	1.13	8.70	87.0	2.34	18.0
—	White swede . . . . .	16.3	87.0	0.94	7.20	84.0	1.49	9.3
—	Green-top swede . . .	8.7	90.0	0.53	5.30	82.0	1.51	8.4
—	Purple-top swede . . .	7.5	90.0	0.56	5.60	79.0	2.25	10.5
—	Green-round turnip . .	11.1	90.5	0.68	7.20	86.0	1.54	11.0
—	Purple-top Scotch . .	11.1	92.4	0.61	8.00	85.2	2.12	14.3
—	Green-top Scotch . . .	12.4	92.2	0.70	8.98	88.0	1.50	12.5
—	Decanter turnip . . .	33.3	92.7	0.48	6.60	84.6	2.00	13.0
—	Green-top Scotch . . .	16.3	90.0	0.84	8.40	84.0	1.92	12.0
—	Scotch purple-top bul- locks . . . . .	17.6	92.0	0.65	8.12	87.0	1.93	14.8
—	Purple-top . . . . .	6.4	90.0	0.82	8.20	82.0	1.95	10.8
—	Swede . . . . .	4.2	90.0	0.42	4.20	85.0	1.59	10.6
—	White stone turnip . .	22.0	92.0	0.80	10.03	90.0	1.42	14.2
—	Scotch purple-top . . .	12.4	92.0	0.87	10.90	87.0	2.08	16.0
—	Ditto . . . . .	19.0	89.0	1.10	10.00	90.0	1.27	12.7
—	Yellow bullocks . . .	16.3	89.0	0.78	7.10	86.0	1.58	11.3
—	Green-top . . . . .	15.0	91.0	0.69	7.70	88.0	1.44	12.0
—	Eye-brights . . . . .	12.4	91.0	0.70	7.80	81.0	2.58	13.6
—	White stone . . . . .	7.5	91.0	0.64	7.10	87.0	1.94	14.9
BEETS.								
166	Yellow globe . . . . .	17.6	91.0	1.02	11.32	90.0	1.40	14.00
168	Long red . . . . .	13.6	91.0	0.64	7.10	90.0	1.79	17.90
170	Ditto . . . . .	25.0	90.0	1.00	10.00	90.0	1.91	19.10
—	Globe . . . . .	—	86.0	0.92	6.60	—	—	—
—	Ditto . . . . .	—	84.0	1.54	9.60	—	—	—
CARROTS.								
—	White Belgian . . . .	—	85.0	0.96	6.40	—	—	—
174	Ditto . . . . .	31.5	85.0	0.77	5.12	75.0	5.32	21.30
176	" . . . . .	23.4	87.0	0.82	6.30	76.0	4.20	17.50
178	" . . . . .	23.4	85.0	0.92	6.10	82.0	2.85	15.80
180	" . . . . .	—	88.0	1.06	8.80	—	—	—
181	" . . . . .	—	86.0	0.95	6.80	—	—	—
182	Artichoke . . . . .	—	84.0	1.79	11.20	47.0	15.00	28.30



TABLE I.

Numbers (corresponding to Tables C & D.)	GRAIN AND ITS VARIETIES.	Moisture in 100 parts of			Sp. gr. of the grain.	Weight of 1 bushel in pounds	Ash in 100 parts of dried			Weight of the straw   chaff (that of the grain = 1000.)	
		grain.	straw.	chaff.			grain.	straw.	chaff.		
WHEAT.											
67	Hopeton wheat	12.00	13.70	12.00	1.374	60	2.00	4.40	10.43	1107	204
—	Hopeton wheat	12.00	12.30	12.00	1.342	59	2.05	4.30	10.58	987	206
—	April wheat	11.00	10.80	12.50	1.387	61	2.01	4.18	7.93	997	278
—	Spring wheat	11.00	12.00	11.00	1.376	58	1.95	5.22	12.99	963	219
—	Bristol red wheat	11.50	12.13	11.00	1.370	61.7	1.74	4.46	13.46	955	216
—	Clover's red wheat	11.00	11.80	11.00	1.383	61.5	1.74	3.61	8.55	978	208
—	Red-chaff Dantzic wheat	12.50	10.40	13.00	1.387	61	1.55	5.43	14.90	1013	185
—	Piper's thick-set wheat	13.50	12.60	12.50	1.350	61	1.71	5.70	9.73	928	173
—	White-chaff wheat	11.50	10.50	12.00	1.313	59	1.74	5.30	11.61	827	155
68	Hopeton wheat	11.00	12.20	11.00	1.354	61	1.69	4.46	12.74	1163	194
69	Spalding wheat	12.00	10.50	11.50	1.377	61	2.05	4.05	8.24	988	223
—	Creeping wheat	11.50	10.52	13.13	1.375	62	1.75	4.83	18.96	958	188
—	Spring wheat	13.00	14.00	12.01	1.370	62	1.83	4.65	16.34	1175	165
—	White wheat	13.50	12.07	13.19	1.368	60	1.94	3.82	14.97	1184	161
—	Spring wheat	12.00	12.44	12.21	1.373	62	1.92	5.79	18.76	1155	175
—	Creeping wheat	12.50	10.46	12.00	1.394	62	1.96	6.14	17.11	1071	116
—	Ditto	13.00	12.13	12.00	1.387	61	2.18	7.77	16.25	1133	199
—	Ditto	13.00	10.05	12.00	1.376	62	1.72	4.54	13.60	1032	166
—	Spring wheat	11.00	11.73	11.00	1.363	62	1.79	6.77	17.12	1068	176
—	Hammond's wheat	13.50	11.00	16.00	1.354	60	2.24	5.22	16.32	932	191
—	Red Britannia wheat	12.00	10.90	13.00	1.369	62	2.07	5.79	16.64	730	169
—	Red wheat	11.50	12.07	13.50	1.352	60	1.98	6.42	15.05	919	243
—	White wheat	13.00	14.00	12.00	1.351	61	1.82	4.65	15.29	1009	178
—	Creeping wheat	12.00	10.84	13.00	1.367	61.5	1.93	4.18	15.40	981	179
72	Ditto	11.50	11.00	11.00	1.365	62	1.95	4.74	17.30	1272	179
73	Ditto	11.00	11.93	12.00	1.372	62.7	1.85	5.22	14.83	1279	186
75	Ditto	11.00	13.00	11.00	1.394	63	1.92	4.94	18.50	1192	181
77	Red-straw white wheat	11.25	—	—	1.385	61	1.91	—	—	—	—
78	Hopeton wheat	9.50	—	—	1.412	60	1.72	—	—	—	—
79	Ditto	11.50	—	—	1.356	56	1.84	—	—	—	—
—	Piper's thick-set	11.50	10.50	12.50	1.339	59	1.95	12.29	17.12	568	191
—	White wheat	12.00	11.70	12.00	1.382	60	1.81	7.92	16.31	1122	207
84	Hopeton wheat	11.50	14.30	13.50	1.403	63	1.81	4.77	14.39	927	148
85	Ditto	12.00	13.30	13.00	1.382	61.5	1.81	4.92	16.42	1009	156
87	Ditto	12.00	11.80	13.00	1.396	62	1.94	4.61	13.55	1066	154
88	Ditto	12.00	12.00	11.00	1.393	60	1.92	5.85	13.64	1246	175
89	Ditto	12.50	13.70	11.50	1.391	62	2.01	4.82	11.70	1167	185
91	Red-straw white wheat	12.00	12.70	12.50	1.381	62	1.95	4.85	11.52	1050	178
92	Ditto	12.50	11.80	14.00	1.392	62	1.97	5.30	16.02	1327	203
94	Ditto	11.50	12.43	13.00	1.362	61	1.81	3.12	8.09	852	192
96	Ditto	11.00	12.30	12.60	1.413	63	1.80	4.79	16.73	1123	205
99	Ditto	11.00	13.19	11.50	1.377	63	2.13	8.47	17.94	1313	197
100	Ditto	12.00	11.63	12.30	1.388	62.5	1.96	5.60	11.00	982	180
—	Ditto	12.00	12.50	12.50	1.386	61	1.94	5.79	12.88	1165	240
70	Hopeton wheat	13.00	—	—	1.371	—	1.70	—	—	—	—
80	French wheat	11.00	—	—	1.341	—	1.74	—	—	—	—
81	Egyptian wheat	10.00	—	—	1.340	—	2.19	—	—	—	—
82	Polish wheat from Odessa	11.00	—	—	1.355	—	1.68	—	—	—	—
83	Marianopol wheat	10.00	—	—	1.369	—	1.88	—	—	—	—
102	Old red Lannias wheat	12.50	—	—	1.387	—	2.10	—	—	—	—
BARLEY.											
105	Unknown	12.00	—	—	—	—	2.43	—	—	—	—
106	Chevalier barley	10.00	—	—	1.260	—	2.50	—	—	—	—
107	Ditto	16.00	—	—	1.234	—	2.82	—	—	—	—
108	Ditto from Moldavia	11.00	—	—	1.268	—	2.38	—	—	—	—
—	Ditto	16.00	—	—	—	—	2.75	—	—	—	—
109	Grains of Chevalier barley	15.00	—	—	—	—	14.23	—	—	—	—
OATS.											
110	Hopeton oats	9.50	—	—	—	—	2.50	—	—	—	—
111	Potato oats	10.50	—	—	1.191	—	2.73	—	—	—	—
—	Ditto	11.00	—	—	—	—	4.20	—	—	—	—
112	Polish oats	11.00	—	—	1.152	—	2.97	—	—	—	—
113	Ditto	13.00	—	—	—	—	3.80	—	—	—	—
114	Unknown	12.00	—	—	—	—	3.12	—	—	—	—
115	Oat-chaff	15.00	—	—	—	—	9.22	—	—	1500	—
116	Rye, English	15.00	—	—	—	—	1.60	—	—	—	—
—	White peas	17.50	15.64	—	—	—	2.39	8.92	—	1188	—
—	Ditto	16.00	15.38	—	—	—	2.68	9.40	—	1333	—
—	Common field-beans	10.00	10.71	—	—	—	2.65	5.56	—	1012	—

will be a similar or the same proportion in the ash of the seed. The oxygen of the bases which have been united with the organic constituents of the plants is by no means constant; in general the difference in the composition of the ash of one and the same vegetable or part of the plant, is far greater than can be ascribed to the mode of analysis.

It will be interesting to compare the results which will be obtained by the continuation of these experiments on the ashes of different crops taken in a series of successive years.

**Wheat, Barley, Rye, Oats.**—The *Royal Agricultural Society* of England, like the kindred institution in Prussia, has devoted a part of its means to the investigation of the mineral constituents of cultivated plants. The two chemists, J. Th. Way and G. H. Ogston, who have been commissioned by the Society to make the analytical part of the experiments, have in their account(1) proceeded on the assumption that the investigation of plant-ashes can only be of value, by including as many cases as are by any means practicable, *i. e.*, by treating the statistical question simultaneously with the agricultural and chemical inquiry. Such a plan merits the highest acknowledgment, since it demands in no ordinary degree the perseverance of the observers, a perseverance which the above chemists, as well as H. Tanner and Arkell, who acted under their direction, have so liberally bestowed on the subject of their investigation, which is to be regarded only as the commencement of a series of experiments undertaken by the same Society. The present investigation only embraces two widely different kinds of cultivated plants, namely, the *cereal plants* (especially *wheat*) and the *turnips or root crops*.

The plants investigated were received from a body of agriculturists, who transmitted with them certain information in printed forms which comprehended the following notifications: 1. method of collecting, packing and transmission; 2. genus, species and variety; 3. locality or place of cultivation; 4. mode of cultivation; 5. general character of the soil; 6. its geological formation; 7. its preparation, manure, &c.; 8. nature of the subsoil; 9. rotation of crops; 10. time of sowing and harvesting; 11. condition and amount of the produce.—Additional particulars regarding the *cereals* of all the samples sent for analysis were obtained in the laboratory, namely, 12. proportional weight of the corn, chaff and straw, respectively; 13. medium length of the stalk; 14. specific gravity of the grain; 15. (with several exceptions) the weight of a bushel of grain; 16. the proportion of water and ashes in the grain, chaff and straw. These details and results, in so far as they bear upon the main object, are communicated in Table I, the numbers of which correspond with those of Tables B to F. For the remaining exten-

Vegetable  
ashes.  
Peas,  
rape.

(1) Journ. of the Royal Agricult. Soc. of England, VII, Part 2, p. 593 to 678.

Vegetable  
ashes.  
Wheat,  
barley,  
rye,  
oats.

sive details, for which we have no space, we refer to the original and confine our notice to the following. Respecting No. 12, it has been considered preferable to establish the relative proportion in the samples themselves (from 30 to 40 plants), rather than to determine it upon the whole produce of the estate or farm, for this double reason, that there the amount of moisture could not have been easily ascertained, and because such determinations are much more uniform when made by one individual than when performed by several; besides, a comparison of the whole produce gave no essential difference. The mean length of the straw in 11 samples grown on College farm was 36 inches; in 12 samples from Mr. Morton, 43·3 inches; in 15 from Sir J. Johnstone, 41·3. The weight of both straw and chaff is by agriculturists generally estimated at about from 1·5 to 2·5 times as great as the weight of the grain; this estimate is decidedly too high; for according to the present results the average is only 1·2 times as great as the weight of the corn.—With respect to Nos. 14 and 15, it was a general opinion that the weight of the single grain of wheat was nearly proportionate to its glutinous constituents or to its real value, but that this weight is only very inaccurately expressed by the weight of a bushel; therefore, for the sake of comparison on the one side the specific gravity, and on the other side the weight of a bushel of each specimen was determined. This last was determined by means of a flask of ascertained capacity holding about 1000 grains of corn, together with a few corrections suggested by experience. The numbers in Table 1 confirm the conjecture previously entertained.

In reference to the ashes of the plants (compare Tables C and D, Nos. 67 to 116), Way and Ogston deduce the following facts as the results of their experiments. The diversity of soil has no definite influence on the amount of ashes contained in plants, yet it appears highest on clayey soils, less so on calcareous, and least of all on sandy soils. The strongest (stiffest) straw contains the largest amount of ash, and *vice versa*. The quantity of ash in the chaff is proportionate to that of the straw, and not to that of the grain: in the latter the amount of ashes also fluctuates, but the variation is confined by narrower limits than in the straw and chaff. The variation in the weight of ashes is as great in corn produced on the same as on different soils; it does not appear to be dependent on climate, nor on the variety cultivated; on the other hand, in all the samples examined it is in an inverse ratio to the produce, so that it appears as if an equal amount of ash-constituents were removed from the soil by the grain whatever the weight of the crop may be. The chemical composition of the particular kinds of soil was not ascertained, yet it was noticed that in the one case where the grain contained least ash and was of the least sp. gr., that sample was grown upon a soil whose exhaustion even before the wheat crop was taken had been proved by two unsuccessful crops of turnips. From the analyses, it appears

that the climate and the soil have as little material effect on the composition as on the amount of the ashes; the preponderance of one of the constituents, as lime, silicic acid, &c., in the soil, does not increase the proportion of the same constituent in the ash of the crop produced thereon.

Though it cannot be doubted that the variations in composition and amount of ash in the same plant, or in the same organ of the plant, depend on causes which will be ascertained by chemical inquiry; yet the data of Way and Ogston have not as yet disclosed such causes. Their opinion is, that the key to the solution of this question is to be found in the fact, that the composition of the ashes does not depend upon the entire organs of a plant, but on the more proximate constituents of the same. In the seed of wheat, for example, which is neither anatomically nor chemically homogeneous, it appears that there exists a perfectly definitive relation between the gluten, starch, &c., and the mineral constituents belonging to them. This is supported by the following results of experiment:

Vegetable  
ashes.  
Wheat,  
barley,  
rye,  
oats.

		A.	B.	C.	D.	E.	F.
Hopeton wheat, four specimens.	Sandy soil	1.403	1.61	39.97	0.78	11.40	0.226
	Ditto	1.396	1.71	43.98	0.75	11.32	0.216
	Clayey soil	1.382	1.63	47.38	0.91	11.52	0.238
	Ditto	1.393	1.69	—	0.92	—	—

(A, sp. grav.; B, quantity of ash; C, quantity of phosphoric acid in the grain; D, quantity of ash in the flour; E, quantity of gluten in the grain; F, quantity of ash in the gluten. B to F are expressed centesimally.)

Whilst for the two kinds of soil the amount of ash in the grain is equal, a decided difference becomes apparent in the amount of that which is contained in the flour; it farther appears that the amount of ash contained in the gluten remains constantly the same. The phosphoric acid in the entire grain is not in proportion to that in the gluten, although in the opinion of Way and Ogston it can scarcely be doubted that the glutinous constituents in the grain are combined with constant proportions of phosphates.—The discrepancies in the amounts of the ashes contained in grain, straw and chaff, are only due to the silicic acid; if this is removed, no perceptible difference remains.—Finally, Way and Ogston endeavour to establish a connection between the moisture of the vegetable dried in the atmosphere and the amount of ash (after deducting the silicic acid); this is at least hazardous and contrary to probability.—The composition of the various ashes presents nothing which could support the view of the mutual substitution of individual bases (especially potassa for soda). In cases where both soil and manure abounded in soda, this latter constituent did not appear to be sensibly increased in the ashes.

The number of observations on barley and oats is too limited to admit of the deduction of tenable conclusions for the present; but

Vegetable  
ashes.  
Wheat,  
barley,  
rye,  
oats.

all agree in this remarkable result, that the ashes of the grain of these two plants do not vary from those of wheat, except in the much higher amount of silicic acid. If the mean constituents of the ash, after deducting the silicic acid, be compared, all essential differences disappear.

**Turnip, White Turnip, Carrot, Artichoke.**—In reference to the root-culture-plants(1) all the samples have been determined as follows: 1. The proportion by weight of the root to the leaves in the plant in the fresh state; 2. the amount of water, and 3. the proportion of ash in both. These data are given in Table K. Hitherto the ashes of only a part of the samples have been analysed; the results are given in Tables E and F, Nos. 154 to 184 inclusive.—As it is difficult to separate perfectly the leaves from the root, as the leaf-stalks penetrate and are partly developed in the latter organ, Way and Ogston lay no absolute, but rather a comparative, value upon the results of their weighing.—The principal results of their analyses are as follows:

In England three varieties are included in the general term *turnip*, namely, proper *turnips*, *swedes* and *hybrids*, all of which possess the same general characters. Among the numerous causes which possibly affect the relation of the leaves to the roots, there is no single one that can be selected as the obviously regulating cause; but in several cases in turnips from the same soil a similar relation of the two is evident.—The quantity of water contained in the turnip amounts on an average to 90 per cent, and in the leaves to 85.5 per cent, but the variations from these mean quantities are considerably greater in the leaves than in the roots. The total weight of a crop of turnips in its green or fresh state is a very unfair measure of its value, that is, of its quantity of dry substance. In this respect there is a great fallacy in the statements of the efficacy of different manures, which appear to cause a proportionally higher production of water than of the real substance of the turnip. In one case a field was cropped with turnips two years successively, the first year without manure, the second with a dressing of bone-ash and guano. The increase of the whole crop produced by the manured field was 35 per cent more than the produce of the field undressed, but only 1.4 per cent when the amount of the root was ascertained. The proportion of ash in the leaves is more than double that of the roots, and in both we perceive very great, and indeed greater differences stated than in the cereal plants, even when allowance is made for the inequality in the quantity of water.—This is conjectured by Way and Ogston to be owing partly to the probable circumstance that the turnip contains more of the soil-constituents in a non-assimilated state than the dry cereal crops, and partly because it is very diffi-

(1) Journ. of the Royal Agricult. Soc. of England, VIII, Part 1.

cult to determine the exact period when the root-crops arrive at maturity.

In the turnip itself, the chemical constituents of the ash present only very moderate variations, but those of the leaves vary very considerably. The amount of mineral soil-constituents removed by the turnips alone from a given surface is nevertheless in different cases very unequal on account of the variation in the amount of ash. So it is with the leaves. But there is a very remarkable adjustment manifest when the ashes of the entire crop (roots and leaves in their natural relation) are taken into consideration, an adjustment which extends both to the weight of the ashes and to the weight of their separate constituents. Hence it would appear as if a crop of turnips has the power of assimilating only a definite amount of phosphoric acid, alkalis, lime, &c., which are, however, very differently distributed, according to circumstances, in the individual organs.—The composition of the turnip-ash in some degree indicates a replacement of potassa by soda; the ash of the leaves on the other hand, exhibits no such indication. Both parts of the plant contain a remarkably large quantity of chloride of sodium, and especially the leaves. The greatest difference in both is in the quantity of lime, which averages 6 times as much in the leaves as in the roots.

Way and Ogston deduce similar, though only preliminary, conclusions, on account of the small number of experiments, from their observations on *mangold-wurzel*, *carrot* and *artichoke*, which we, for this reason, omit for the present. Upon the whole the three roots exhibit a pretty similar deportment, and especially in the quality and quantity of mineral constituents which they require. This circumstance is remarkable, for the carrot will yield a fair crop without manure, which is not the case either with turnip or mangold-wurzel.

The analytical processes offer little that is new. In order to determine the quantity of ashes which they contain, the various parts of the vegetables were burned to a white ash in a shallow platinum dish; in such ashes as were easily fused the incineration was effected at a lower temperature, and the unconsumed carbon deducted. In analysing the ashes from 30 to 40 times more substance was employed, and this was heated to dull redness till the carbon formed ceased to glimmer. Ashes containing a large proportion of silicic acid, or such as retained too much carbon, were subjected to a second ignition with an equal weight of nitrate of baryta. On this subject, and on the determination of phosphoric acid, see pp. 307 and 417.

After the publication of these analyses, Way and Ogston became acquainted with the observations of Mitscherlich and H. Rose regarding the influence of incineration upon the composition of the ash. They immediately commenced a series of experiments on this subject, from which they conclude that the method of preparing ashes practised by them occasions a perceptible loss only in one of

Vegetable  
ashes.  
Turnip,  
white  
turnip,  
carrot,  
artichoke.

Vegetable  
ashes.  
Turnip,  
white-  
turnip,  
carrot,  
artichoke.

the constituents of the ash, namely, in the sulphur (of the sulphuric acid). On this account (1) Way and Ogston performed the analysis of the several plants, which are distinguished by the amount of sulphur which they contain, the results of which are given in Nos. 37—58 inclusive, Nos. 61—66 inclusive, Nos. 194—196 inclusive, and in Nos. 200 and 201 of Tables B, C, and F. They determined the sulphur always according to a method which they recommend for this purpose, and in which the unaltered substance of the plant is oxidised by nitric acid before combustion. The results obtained are given, together with the quantities of water contained in the plants examined, in Table L.

**Clover; Sainfoin; Italian Rye-grass.**—The comparative analyses of the hay of red and white clover (Nos. 61—64 incl., Table C) refer to two samples, the one from a sandy soil, the other from a clayey soil. The comparison shows that the diversity of soil is inappreciable in the composition of the ashes of the whole plant; yet the samples investigated prove that in different varieties of the plant there is a perceptible difference in the ashes.—In like manner, the ash of sainfoin (Nos. 65 and 66 of Table C) and that of the Italian rye-grass (Nos. 200 and 201 of Table F) show no perceptible difference of composition whether the plant has been collected in blossom or in seed. Clover and sainfoin belong to the series of plants on which, according to experience, gypsum exercises a beneficial influence. In fact, the quantity of sulphur in the form of sulphuric acid, which the first withdraws from the soil, is sufficient to render it probable that an introduction of sulphuric acid is to a certain extent the object of manuring with gypsum. But a glance at Table L shows that other cultivated plants, namely, peas, hops, and others, on which gypsum has not the same effect, absorb, nevertheless, an equal quantity of sulphur from the soil.

**Hops.**—The ashes of the three varieties of the strobiles of the hops exhibit considerable differences in the quantities of silicic acid and potassa without the decrease of potassa being compensated by the increase of soda. It is, however, doubtful whether these fluctuations are to be ascribed to the diversity of the soil or to the differences in the varieties of the plant. The plants Nos. 195 and 196 (Tables F and L) were sulphurised, a circumstance which, according to Way and Ogston, explains the higher amount of sulphur found in these specimens when compared with that of No. 191.

**Peas; Beans.**—The following analyses of two varieties of peas, and two of beans, as well as of the haulm, were instituted with special regard to the condition of the soil; the first analysis was made with the same seed which was sown, and the other with the seed and haulm produced from the seed of the first experiment; one crop was

produced on a sandy, and the other on a clayey soil. In general, the effects attributable to the difference of soil and to the different varieties of the plant are of slight importance; but in this statement the produce of each crop is not taken into account. Farther, it was remarked that the ashes of peas are as different from each other as from the ashes of beans; and this is the case both with the straw and the seed. These results are confirmed, moreover, by the analysis of pea- and of bean-ashes, mentioned in Way and Ogston's treatise, quoted at page 474 (see Tables B and C, Nos. 33—36 incl. and Nos. 59 and 60); only one exception is to be noted, namely, that the bean-straw shows a considerable preponderance in alkalies. If the amount of the ashes of the whole crops be taken into account, it appears that the bean- and pea-seed assimilate the mineral constituents in tolerably equal degrees, but that the straw of the bean only absorbs half as much of these as does the straw of the pea; the difference for the most part consisting in lime and magnesia. We should, however, be deceived were we to attribute that difference to the unequal produce; it rather depends on the difference in the amounts of ash (5 per cent in the bean, and 7·5 to 8 per cent in the pea), which is, however, not constant, becoming, for example, according to the results contained in the other treatise above-mentioned, almost imperceptible.

**Linseed and Oil-cake.**—While engaged in investigating the nutritive properties of oil-cake(1) and oleaginous seeds, Way has taken the opportunity of publishing an analysis of the ashes of linseed (No. 149), by himself, of linseed oil-cake by Ward (Nos. 145 to 148 incl.) and of rape-seed oil-cake, by Eggar (No. 144 of Table E).

As an appendix to the treatise noticed at p. 413, H. Rose has published several analyses of the ashes of plants(2), which under his direction, had been conducted by Weber and B. W. Bull, with the view of ascertaining the influence of the method adopted upon the result. Nos. 29a to 32d inclusive, of Table B, are ashes of peas; Nos. 139a to 142 Table E, of rape; Nos. 103a to 104d Table D, of wheat, and Nos. 204a to d Table F, of pale beer lees. Nos. 31, 32, 141, 142 are the results of direct incineration; the remaining numbers are obtained by the successive exhaustion with water and hydrochloric acid and incinerating the remaining charcoal.—The direct incineration is very difficult where the alkalies are preponderant, and comparatively easy when the earths prevail. In every case, but especially in the former, the greater part of the chlorides of the alkali-metals are volatilised in this operation. The amount of 6·5 per cent of soda in the rape-straw which was incinerated directly, if no error attaches to

(1) See p. 496.

(2) Pogg. Ann. LXXVI, 338; J. Pr. Chem. XLVIII, 43; Phil. Mag. [3] XXXV, 171, 271.



Vegetable  
ashes.  
Peas, rape,  
wheat.

the transcription of the figures, is very remarkable; whilst the analysis by the new process gives no soda, and also no equivalent of chloride of sodium. One hundred parts of the ash-constituents in the vegetables investigated are distributed in the various solvents as under:

	Peas.*		Rape.†		Wheat.‡		Lees.§
	Grains.	Straw.	Grains.	Straw.	Grains.	Straw.	
In the aqueous extract . . .	23·16	27·00	9·50	39·59	36·80	31·79	27·24
„ hydrochloric extract . .	21·48	65·87	35·60	45·91	43·93	13·39	37·70
„ carbonaceous residue . .	55·36	7·13	51·90	14·50	19·27	55·82	35·06

\* No. 29 a, b, c, d, and 30 a, b, c, d of Tab. B.

† No. 139 a, b, c, d, and 140 a, b, c, d of Tab. E.

‡ No. 103 a, b, c, d, and 104 a, b, c, d of Tab. D.

§ No. 204 a, b, c, d of Tab. F.

Baer(1) has published a chemical analysis of the ashes of peas, of pea-haulm and of rape-haulm without giving any details regarding the modes of cultivation. As the determination of their amount of moisture is omitted, the determination of the proportions of ashes is of no value. The vegetables were first carbonised by Rose's method, then exhausted, and finally the residue was incinerated with the aid of a current of oxygen. The results of the analysis are given in Nos. 17 and 48 of Table C, and in 143 of Table D, as they were calculated by Baer, after deducting the carbonic acid and sand. It should be remarked, however, that the carbonic acid was determined by a method which Baer himself considers to be fallacious.—By the method of Heintz he found in peas 0·0288 per cent of sulphur.

**Different Esculent Vegetables.**—The mineral constituents of the following esculent vegetables have been investigated by Th. J. Herapath(2) (Nos. 1—21 of Table G.) 1. *Cochlearia anglica*, scurvy-grass; this is not actually a nutritive substance, but rather an anti-scorbutic. It was collected on the banks of the Avon, being produced on loose debris of red-sandstone, regularly exposed to the tide. 2. *Apium graveolens*, celery. 3. *Crambe maritima*, sea-kale; ash of the fully developed leaves and stalks. 4. The same, young bright-green sprouts; both grown on loose sandy garden-soil on calcareous millstone-grit, dressed with stable dung. 5. *Asparagus officinalis*, cultivated near Bristol, upon garden-soil, as No. 4. 6. The same, wild, from the daily-flooded alluvial soil on the banks of the Avon, the plants fully developed. 7. The sprouts of the same as they are eaten. 8. *Brassica oleracea*, var. *botrytis*, grown on loamy, very

(1) Arch. Pharm. [2] LVII, 138.

(2) Chem. Soc. Qu. J. II, 4; J. Pr. Chem. XLVII, 381; Ann. Ch. Pharm. LXXII, 350.

heavy, well-manured soil in Cornwall; quite young plants. 9. *Phaseolus multiflorus*, kidney beans; fresh young plants. These, and all the following plants, were produced on the same fertile, well-manured and watered sandy arable land, near Bristol. The subsoil of this ground is millstone-grit and new red sandstone, the latter of which abounds in sesquioxide of iron, carbonate of lime and carbonate of magnesia. 10. *Allium sativum*, fresh plants (with or without roots is not stated). 11. *Brassica rapa*, fresh roots. 12. *B. campestris*, var. *napobrassica*, swedes. 13. *Beta vulgaris*, beet, var. long red. 14. *Raphanus sativus*, radishes. 15. *Daucus carota*, carrot, var. long scarlet. 16. *Pastinaca sativa*. Five varieties of *Solanum tuberosum*, namely: 17. *White apple*; 18. *Princess beauty*; 19. *Axbridge kidney*; 20. *Maggie*, or *Maghie*; 21. *Forty-fold*. Commencing with No. 11, the roots or tubers were examined.

Vegetable  
ashes.  
Different  
esculent  
vegetables.

The numbers in the tables express, generally, the mean of two analyses. Herapath deduces from his results a confirmation of the often-observed fact, that the mineral constituents of vegetables are, by cultivation, considerably modified in their composition and mutual relation, and also that the saturating capacity of the ash, which is expressed by the amount of oxygen contained in the bases present, does not always remain constant (being in cultivated asparagus = 7.52, in the wild = 5.69). Finally, he deduces the conclusion that the alkaline salts in all young sprouts and roots show a considerable preponderance when compared with the earthy salts. He might have added that his analyses of plants, not investigated heretofore, have extended our knowledge of the fact that the soluble portions of the ashes of culinary vegetables in the fresh state amount to at least 0.5, often to 0.75, and sometimes even exceed 0.8 of the ashes.

**Asparagus; Red Cabbage.**—Schlienkamp(1) has investigated the ashes of asparagus, and of red cabbage (Nos. 189 and 190 of Table D.) He exhausted with water the vegetable, carbonised it at a moderate temperature, incinerated the carbonaceous residue in the muffle, and mixed the ash with the extract for analysis. The carbonic acid was determined by the method of Fresenius and Will; the phosphoric acid as pyrophosphate of magnesia, after it had been precipitated by acetate of lead, and the lead-salt decomposed by sulphide of ammonium. The separation of the manganese from the iron was effected by carbonate of soda in the acetic solution.

The asparagus, dried at 100°, lost 93.6 per cent of water; the fresh plant yielded 0.426 per cent of ash. For red cabbage no similar determinations have been made.

Vegetable  
ashes.  
Lettuce  
and  
beetroot.

**Lettuce and Beetroot.**—F. Griepenkerl(1) has published the results of his analysis of the ash of lettuce, and of beetroot, without any farther remarks. We do not know, in reference to the former, how much the leaves and stem respectively contributed, neither are we informed how much fresh substance is represented by that which was dried at 100°. The beetroot contained between 87 and 88 per cent of water. The results of the analyses are given in Nos. 173 and 187 of Table F.

**White Cabbage; White Turnip.**—K. Stammer(2) has investigated the ashes of the white cabbage (*Brassica oleracea*) and the turnip (Nos. 172 and 188 of Table F.) The fresh cabbage (the leaves with or without the leaf-stalk not stated) lost in the water-bath 93·44 per cent of water, and yielded 0·76 per cent of ashes. The turnip gave, in a similar manner, 93·31 per cent of water, and 0·46 per cent of ashes. The incineration was effected in a muffle, and yielded a white ash, which was not fused. The carbonic acid was determined by Fresenius and Will's method, the phosphoric acid as phosphate of magnesia, from the precipitate with sesquichloride of iron and acetate of soda (after the separation of the sesquioxide of iron by sulphide of ammonium).—Both ashes were free from manganese and soda.

**Topinambour.**—Payen, Poincot and Fery(3) have investigated the ash of the tubers of topinambour. Two specimens, namely, the one (I) described at p. 331, and another one bought in the market (II), gave the following results:

	I.	II.
Silicic acid . . . . .	2·00	6·95
Carbonate of lime . . . . .	4·12	} 10·23
„ „ magnesia . . . . .	1·94	
Phosphate of lime and magnesia . . . . .	33·59	} 16·62
Alumina . . . . .	1·44	
Chloride of potassium . . . . .	8·36	10·75
Sulphate of potassa . . . . .	11·16	10·66
Phosphate of potassa . . . . .	28·40	8·45
Carbonate of potassa with traces of soda . . . . .	9·93	36·34
	100·94	100·00

**Diseased Potatoes.**—Fr. Griepenkerl(4) is of the opinion, previously expressed by Liebig, that the principal cause of the potato-disease is to be sought for in the obstructed circulation of the sap, induced by an abnormal condition of the atmosphere; he believes,

(1) Ann. Ch. Pharm. LXIX, 360 and 361.

(2) Ann. Ch. Pharm. LXX, 294.

(3) Loc cit. p. 331 of the present Report.

(4) Ann. Ch. Pharm. LXIX, 354.

Vegetable  
ashes.  
Diseased  
potatoes.

however, that it is likewise dependent on the soil and mode of cultivation, and on the atmospheric relations of the locality(1). In hopes of obtaining in this direction a more satisfactory explanation of the disease, Griepenkerl has undertaken a comparison of the ashes of sound and diseased potatoes (Nos. 185 and 186, Table F.) Both were of one sort, and from the same field, and were examined (dug up ?) in the month of June. In reference to the state of the diseased potatoes, Griepenkerl only notes that the disease had just commenced, but he does not state anything regarding the particular condition of the tubers, neither does he intimate whether or not he investigated the entire tubers, or merely the diseased substance, although these circumstances would materially influence the results. The sliced and dried tubers were, without difficulty, incinerated in porcelain dishes in the muffle. The healthy tubers lost "about" 78.92 per cent of water, the diseased "about" 69.65 per cent. The amount of ash fluctuated in the "sound *and* diseased potatoes," between 4.86 and 6.00 per cent of the dried substance. From the precipitate produced by acetate of soda and sesquichloride of iron the phosphoric acid was determined as phosphate of magnesia (the precipitation of sesquioxide of iron having been prevented by the addition of tartaric acid to the hydrochloric solution). It appears from a comparison of the percentage-composition, that the ash of the diseased potatoes contains about an equal amount of phosphoric acid and potassa, and 1.1 less of chloride of potassium, 1.18 less of magnesia and 0.83 less of lime; moreover, that the ash of the former contains 1.18 more of sulphuric acid, 1.08 more of silicic acid and 0.55 more of sesquioxide of iron than the ash of the sound potatoes. Consequently, if Griepenkerl finds that the influence of the disease upon the nature of the mineral constituents is expressed chiefly by the smaller quantity of magnesia and lime, this view is not quite justified by the foregoing numbers. Moreover, it is evidently necessary to the success of such a comparison, that the constituents of the ashes should be calculated for equal weights of the substance of the potato. But after all, it remains uncertain whether the differences exhibited are the causes or the consequences of the potato-rot.

**Flax.**—We have published in our last Report, II, p. 327, the results of the researches of Sir R. Kane on the cultivation of Belgian and Dutch flax; we have now to report upon similar investigations of Russian flax, which have been published by J. E. Mayer and J. S. Brazier(2). The specimens were grown in the maritime

(1) Namely, that the active resistance against the external destructive causes is, to a certain degree, diminished by the want of the conditions necessary for the maintenance and manifestation of the vital functions of plants.

(2) Chem. Soc. Qu. J. II, 78; Ann. Ch. Pharm. LXXI, 314.

Vegetable  
ashes.  
Flax.

provinces of Esthland, Liefland, Kurland and in the interior of Lithuania.

As to the preparation of the ash, the stalks were burned over a porcelain plate in the open air, and the still adhering carbon was destroyed by heating it to redness with protoxide of mercury in a platinum dish.—The Liefland flax yielded on the average 4.129, the Kurland, 3.636, the Lithuanian, 2.302, and the Esthland, 4.019 per cent of ash of the composition given under Nos. 150—153 of Table E.

The results thus obtained when compared with those of Kane, with the exception of lime and phosphoric acid, in which they pretty nearly coincide, present very considerable discrepancies. In the former the amount of soda is very much less than that of the potassa, whilst in the specimens investigated by Kane these constituents occur in nearly equal proportions. Kane, moreover, found a much smaller quantity of magnesia in his specimens, but more iron, and far more chloride of sodium than that obtained by Mayer and Brazier.—In the majority of Kane's specimens the silicic acid is smaller than in those of Mayer and Brazier; finally, the latter chemists found no alumina; the former indicated as much as 7 per cent. Without entering into a farther comparison, the results of Mayer and Brazier afford additional evidence that flax is one of the most exhaustive crops. But as the prepared flax takes away very little of the mineral constituents, which remain for the most part in the refuse, this observation affords an important hint for improving the culture of flax, namely, by employing the waste of the flax as a manure for a subsequent crop. The soils on which the above samples grew were also analysed by Mayer and Brazier, who confine themselves, however, to stating the deportment of the soils with solvents, together with their percentage-composition.

The following tabular statement shows the deportment of the soils with solvents :

	Liefland.	Kurland.	Lithuania.	Esthland.
Soluble in } water. } Mineral substances . . .	0.086	0.170	0.153	0.150
	0.229	0.312	0.442	0.458
Together	0.315	0.482	0.595	0.608
Soluble in hydrochloric acid . . .	7.259	6.917	7.243	8.712
Insoluble residue . . . . .	92.425	92.601	92.162	90.681
	99.999	100.000	100.000	100.001

The elementary constituents of these soils are given in Nos. 15—18 of Table A. The whole series of the soils is distinguished by abounding in alkalis, especially potassa, and in phosphates, as

might be expected from the ash-constituents of the corresponding kinds of flax.

Vegetable  
ashes.  
Poppy  
seed.

**Poppy Seed.**—Sacc(1) in his investigations of poppy seeds has also given an analysis of the ash-constituents which they contain. Assuming that the expressed oil contains no such constituents (an assumption unsupported by direct experiment, and, moreover, improbable, from the fact that expressed oil commonly does contain mucilage, albumin, &c.), he confined his investigation to oil-cake, and without describing his method of incineration and analysis, published the results which are given in Table F, No. 193. The seeds yielded in the fresh state, 5·4; the oil-cakes, 8·6 per cent; in the dry state the seeds, 7·0; the oil-cake, 10·6; the latter treated with ether yielded 13·2 per cent of ash.

**Abies Pectinata. Fir-wood.**—Sacc(2) has, moreover, examined the ash of *Abies pectinata*. The wood which he made use of was obtained from trees of average height, grown upon calcareous soil; the chips from the trees which had been felled in the autumn and were sawn up in February were carefully mixed; they contained, as a mean, 38·00 per cent of water, and 0·554 per cent of a grayish-white ash (No. 192 in Table F). After exhaustion with a mixture of equal parts of hydrochloric acid and water, and washing, it left only 0·071 per cent of a dazzling white ash. The method of analysis is not described.

**Olive-tree.**—A. Müller(3) has analysed the ashes of the leaves, wood and fruit, as well as the native soil of an olive-tree (*Olea Europæa*) from the neighbourhood of Nice. The incineration and examination of the ash were conducted essentially according to the method given by Erdmann; the phosphoric acid, however, was determined by a special method (See p. 397), and the magnesia and potassa were estimated by indirect determination in the solution from which the phosphoric acid had been separated by a salt of sesquioxide of iron. The results thus obtained are given in Nos. 197 to 199 of Table F.

With regard to the soil, A. Müller has omitted to give any information respecting its physical and geological relations, its state of culture, and the various mechanical operations by which it was prepared for analysis; the results, therefore, are wholly destitute of interest.

**Wongsby-fruits.**—In the paper quoted at p. 315, Stein(4) has communicated an analysis of the ash of the Wongsby-fruits (No. 203 of Table F.) The phosphoric acid was determined according to Rose's method by means of mercury.

(1) See p. 494.

(3) J. Pr. Chem. XLVII, 335.

(2) Loc. cit. p. 327.

(4) Also Dingl. Pol. J. CXIV, 136.

Vegetable  
ashes.  
Hay.

**Hay.**—In the autumn of 1847 upwards of 1000 cwts. of hay were burnt in a rick in the estates of the Count Wenckheim, in the Banat. The ash remained in the form of a vitreous mass; an analysis by Hubert(1) gave the results stated in Table F, No. 202.

**Seeds of Madder.**—In the analysis of the ash of the seeds of madder procured from Avignon, J. Schiel(2) obtained the results given in No. 191 of Table F; he omits, however, to state whether the amount of ash was determined in the fresh or in the dried seeds.

**Fucus.**—According to Malaguti, Durocher and Sarzeaud(3), the proportion existing between the soluble (in water?) and insoluble portions of the ash in

<i>Fucus canaliculatus</i>	is that of	75	to	25
„ <i>vesiculosus</i>	„	53	:	47
„ <i>serratus</i>	„	41	:	59
„ <i>ceramoides</i>	„	35	:	65
„ <i>nodosus</i>	„	62	:	38
<i>Ulva compressa</i>	„	41	:	59

**Articles of Food. Water.**—Castelnau(4) has proposed to construct the filters in ordinary use in Paris in such a manner that the water shall regain the air which it has lost during the filtration.—Mozière(5) directs that the filter be covered with a layer of animal charcoal to remove the lime from water intended for domestic uses.

With regard to the action of water upon lead, see p. 439.

**Wine.**—In a treatise upon the treatment of wines by Vergnette-Lamotte, which has been reviewed by Bussy(6), the former proposes some improvements in the clarification of wine with isinglass.—He remarks that the success of this method depends upon the combination of the isinglass with the tannin, forming a precipitate which envelopes and carries down with it the suspended impurities; he explains that the inutility of repeated clarifications with isinglass results from the circumstance that, in the later operations, this substance finds no more tannin with which it may combine. In this case, and generally, in the case of wines poor in tannin, such as some kinds of Burgundy, he proposes to add tannin at first, and recommends for this purpose in place of nut-galls or catechu, which, though very suitable, are far too costly, a hot infusion of grape-seeds, the husks of which, according to his experiments, contain abundance of tannin.

(1) J. Pr. Chem. XLVI, 212.

(2) Ann. Ch. Pharm. LXIX, 143.

(3) Loc. cit. p. 425.

(4) Dingl. Pol. J. CXII, 462.

(5) J. Chim. Méd. [3] V, 65; Dingl. Pol. J. CXII, 438.

(6) Bull. Soc. d'Enc. 1848, 645; Monit. Industr. 1848, No. 1300; Dingl. Pol. J. CXI, 147.

Vergnette-Lamotte(1) has, moreover, studied the action of frost upon wine, which is rendered practically useful in Burgundy. When the atmosphere exhibits a degree of cold of, at least,  $-6^{\circ}$ , the wine is exposed in casks (each holding less than 100 litres) during the night, to a north wind, in a place which is shaded during the day. Two different phenomena may then be observed. Even before the wine has attained a temperature of  $0^{\circ}$ , colouring matter is separated together with nitrogenised matters and much bitartrate of potassa, producing a turbidity which disappears again at the ordinary temperature; this precipitate is more abundant in red, light, and young wines than in white, strong, and old wines. The wine decanted from this precipitate is found by experience to have a purer flavour, to be hotter, and especially stronger than before, but at the same time remarkably inferior in bouquet. At about  $-6^{\circ}$  a crystallisation of shining leaflets of ice commences, which gradually form a continuous tissue throughout the vessel. The portion still remaining liquid is now drawn off without shaking the cask before the temperature rises, and set aside in the cold; in from 4 to 6 weeks the precipitate separates entirely, and the wine may now be drawn off a second time. In an economic point of view, Vergnette shows that this process of freezing is only applied with advantage to wines of medium quality, and not to strong or light wines.

Boussingault(2) has communicated some experiments upon this subject, which entirely confirm the observations of Vergnette. Mixtures of water and alcohol containing from 13 to 15 vols. per cent of the latter, froze exactly like wine, whilst mixtures containing from 20 to 45 per cent remained perfectly liquid. Boussingault regards as unfounded the view advanced by Vergnette, who considers the leafy crystals as a definite compound of alcohol and water not pre-existing in the wine; Boussingault, however, also found that the ice formed contained alcohol.—Bussy(3) in his review of Vergnette's investigation, likewise refutes this opinion by the older observations of Gay-Lussac, who completely separated the alcohol from the wine by distillation *in vacuo*, as well as by means of deliquescent salts.

Schubert(4) has published some observations upon the influence of time upon the wine, and in order to ascertain the nature of this influence, has tested 67 sorts of wine from the neighbourhood of Würzburg; for the determination of the extractive matter and spirit, he employed the hallymeter of Fuchs, and made use of Otto's

(1) Ann. Ch. Phys. [3] XXV, 353; J. Pr. Chem. XLVII, 176; Dingl. Pol. J. CXII, 300.

(2) Ann. Ch. Phys. [3] XXV, 363; Ann. Ch. Pharm. LXX, 308; J. Pr. Chem. XLVII, 181; Dingl. Pol. J. CXII, 306.

(3) Moniteur Industr. 1848, No. 1297; Dingl. Pol. J. CXI, 229.

(4) Loc. cit. p. 197.



Wine.

acetimeter to indicate the amount of acid present, which he calculates as tartaric acid; the sp. gr. of each specimen was also determined. The amount of alcohol contained in these wines (of different localities and ages, some of them more than 100 years old), varied between 10·7 and 5·3 per cent by weight; the amount of extractive matter (with two exceptions, where it amounted to 7·2 and 9·4 per cent), between 4·4 and 1·1 per cent; the acid present, between quantities corresponding to 1·2 and 0·4 per cent of tartaric acid. The sp. gr. of the various specimens lay between the extremes 1·0833 and 0·9762. From his own investigations, compared with those of Fischern, Lüdersdorff, Fresenius, Liebig, and Geiger, Schubert believes himself justified in inferring: 1. that the amount of alcohol decreases only during the period of secondary fermentation, *i. e.* during the first year, but not after longer standing, because (according to his view) the wood of the cask at first allows only the alcohol of the wine to pass more readily, but afterwards the wine, when it is reduced to a certain strength, passes itself; 2. that keeping particularly favours the formation and concentration of the ænanthic ether, and 3. effects the separation of the dregs; 4. that keeping diminishes the amount of acid in consequence of the concentration of the liquid, and the deposition of bitartrate of potassa. If Schubert maintains that there is a relative diminution of the acid in the wine, it is incumbent upon him to bring this deposition of the bitartrate of potassa into accordance with the laws of crystallisation and with the results of experience. He infers moreover, 5. that the greater intoxicating power of new wine, or the loss of this power in the secondary fermentation, is "doubtless," due to the formation of a more intimate chemical combination of the alcohol with water (which opinion, however, is not supported by any experimental results). In order to determine the amount of sugar present in several of the wines submitted to examination, Schubert has subjected the specimens to the action of yeast to produce a secondary fermentation, and has determined the weight of the carbonic acid evolved, however, without drying it, and regardless of the amount which might be produced from the yeast, has taken it to represent the amount of grape-sugar.—Since it is impossible to obtain accurate results by this method, we pass over these experiments and the conclusions deduced from them.

R. Kersting(1) has investigated the wine from the Bergstrasse of different years and vintage. He determined the percentage weight of the various constituents as follows: 1. anhydrous alcohol from the sp. gr. of the distillate; 2. grape-sugar, according to Trommer's method, by means of a graduated alkaline solution of oxide of copper; 3. tartaric acid by adding a graduated solution of potassa

until the liquid was neutral to test-paper (the numbers refer to crystallised tartaric acid); 4. extractive matter and salts from the residue dried at 100° after deducting the acid and sugar; 5. the amount of water by difference; 6. the sp. gr. in the usual manner (water = 10,000). Kersting has named the vintage and variety of the grape in only a few cases. He found in 100 parts of the various kinds.

Wine.

	1.	2.	3.	4.	5.	6.
Auerbach (Riesling) 1846	10·66	0·22	0·60	1·64	86·88	9924
" " "	10·44	0·46	0·71	1·27	87·12	9933
(Riesling) " "	9·97	0·18	0·61	0·93	88·31	9916
" " " "	10·55	0·23	0·65	1·16	87·41	9918
" " " 1834	9·05	0·20	0·69	1·20	88·86	9934
(Riesling) " "	8·81	0·15	0·67	0·83	89·54	9930
" " " "	8·22	0·28	0·81	1·29	89·40	9936

**Distinction between Grape- and Apple-wine (Cyder).—**Winckler(1) has investigated the distinctive characters of the wines obtained from grapes and apples. He finds that the wine from apples is distinguished by the absence of bitartrate of potassa and of œnanthic acid, by its containing a smaller amount of alcohol, and more tannin, but especially, by the presence of a characteristic acid, which he regards as lactic acid, notwithstanding that this opinion is not confirmed by the degree of solubility of its salts with oxide of zinc, lime and magnesia.

**Spirit from the Berries of the Mountain-Ash.**—Liebig(2) has observed that the juice of the berries of *Sorbus aucuparia* underwent, at the ordinary temperature, a spontaneous vinous fermentation, which proceeded in a regular manner, and furnished, on distillation, about 4 p. c. of a spirit similar to *Kirschwasser*, of a pure taste, and containing about 50 per cent of alcohol. He believes that by the addition of the juice of these berries to potatoes, the formation of fusel oil may be prevented.

**Milk.**—J. Reiset(3) has investigated, in a series of experiments, the facts previously observed by Parmentier and Deyeux, and by Quevenne and Donné, as well as by Pélilot, that when the milking first commences, the milk has a different composition to that which is subsequently drawn from the udder. The two cows which were made the subjects of experiment were turned out to pasture during the day, and shut up in the stall at night without more food. At each milking, the milk was fractioned off, and, as soon as drawn,

(1) Jahrb. Pr. Pharm. XIX, 335.

(2) Ann. Ch. Pharm. LXXI, 120.

(3) Ann. Ch. Phys. [3] XXV, 82; Ann. Ch. Pharm. LXXI, 231; J. Pr. Chem. XLVI, 500; Dingl. Pol. J. CXI, 390 (in abstr.); Froriep's Notizen aus d. Natur- u. Heilk. 1849, No. 197.

Milk.

evaporated to dryness in the water-bath. No remarkable difference was observed when the milk was drawn at periods of two hours or oftener. When, however, the milk had remained in the udder for four hours or longer, the solid constituents in the last portion always exceeded, and often very considerably, those in the first portion. After an interval of about twelve hours, the proportion borne by the dry residue of the portion first drawn, to that left by the last portion, was that of 100 to between 50 and 60; after five or six hours, of 100 to between 56 and 81. The analysis of the solid constituents showed that the amounts of ash and of nitrogen contained in the two portions were virtually constant, the observed variations being due merely to those in the amount of butter present. The ratio of the butter in the last portions to that in the first, was 100 to between 27 and 11, according as the milk was drawn every five hours or oftener.—This circumstance cannot be explained by the position of the cow's udder, which favours the accumulation of cream upon the surface, because the experiments made by Reiset upon the milk of women exhibit variations in the same direction, though within far narrower limits.—Incidentally to these inquiries, Reiset remarked that the milk of cows is always richest immediately after food has been taken, and that from this time, its solid matter decreases. He likewise controlled the results of Donné's lactoscope, which do not testify in favour of the accuracy of the instrument.—In order to exhibit the great practical importance of his observations, Reiset states that the milk which he examined gave, in all, 4·5 per cent of marketable butter, whilst, by fractional milking, from 6·6 to 8·4 per cent might have been obtained from the last portions.

Lignac(1) has made known a process for the preservation of milk, with a view to its transportation to a distance. He evaporates the milk (with the addition of 75 grms. of sugar to every litre), in a water-bath, to  $\frac{1}{5}$  of its original volume, and seals up the evaporated mass in tin cases. When required for use, the mass is heated to boiling with four times its weight of water.—According to Payen(2), milk thus preserved can scarcely be distinguished, in tea, coffee, &c., from fresh milk which has been boiled and sweetened.

F. Louis(3) has taken out a patent in England for two methods of effecting the same object. One of these is essentially the same as the foregoing, except that the milk is evaporated farther, and dried up to a solid mass. According to the second method, the milk is coagulated by an acid, the curd washed, pressed, and, after addition of

(1) *Compt. Rend.* XXIX, 144; *Instit.* 1849, 249; *J. Pharm.* [3] XVI, 214; *Dingl. Pol. J.* CXIII, 454. For the description of his apparatus, patented in England, see *Hingl. Pol. J.* CVIII, 363.

(2) *Compt. Rend.* XXIX, 495; *Monit. Industr.* 1849, No. 1397; *Dingl. Pol. J.* CXV, 71.

(3) *Chem. Gaz.* 1849, 48.

very little bicarbonate of soda, mixed with the whey evaporated to dryness.

Bethel(1) proposes to preserve the milk by boiling it, and afterwards impregnating it with carbonic acid by means of a forcing-pump.

With regard to the determination of milk-sugar in milk, see pp. 86 and 421.

**Wheat and Wheaten Bran.**—E. Péligot(2) has made several determinations of the proximate constituents of wheat; these determinations have been effected (unless otherwise stated) on, in all, 14 specimens of wheat produced from various countries.

The water amounted, as a minimum, to 13·2; as a maximum, to 15·2; and, on an average, to 14·1 per cent. Hence it is very constant. The inorganic salts varied (in 7 determinations) from 1·4 to 1·9 per cent, amounting on an average, to 1·7 per cent.—Péligot designates by the name of cellulose that substance which remains behind after twenty-four hours' digestion with sulphuric acid (containing 6 equivs. water) at a temperature of 100°, washing with water, solution of potassa, alcohol and ether, and drying the undissolved portion. This substance is stated to exhibit its cellular structure unchanged under the microscope; its quantity varied, in five determinations, from 1·4 to 2·3, the mean being 1·46 per cent.—Anhydrous ether extracted from the perfectly dry wheat 1·0 to 1·9, as a mean 1·3 of fatty matter, Péligot states that he has observed a striking influence exerted by this fat in the preparation of gluten (by washing the dough); the wheat freed from fat, forms, in this operation, an emulsion, in which the glutinous portion is incapable of acquiring coherence; the presence of too large a quantity of fat in the meal likewise prevents the formation of coherent gluten, and therefore, of a fine dough; the sifting off the bran is said to have for its object, not only the separation of the cellulose, but likewise of the excess of fatty matter.—The amount of gluten (albuminous portion insoluble in water) is calculated from that of the nitrogen, and was found to coincide with the result of the determination by kneading. It exhibited greater variations than the other constituents, namely, from 8·1 to 19·8 per cent (mean 12·5 per cent).—In the aqueous solution evaporated to dryness, Péligot determined the nitrogen, deducted the albumin thence calculated (1·4 to 2·4, as a mean 1·7 per cent) and considered the remainder, in which he found no sugar, as dextrin. This last varied between 5·9 and 10·5, amounting, as a mean, to 7·25 per cent.—After Péligot had endeavoured, without success, to determine the starch in the wheat exhausted with alcohol and ether, sometimes by treatment with

Milk.

(1) Chem. Gaz. 1849, 326.

(2) Ann. Ch. Phys. [3] XXIX, 5; J. Chim. Méd. [3] V, 361; Compt. Rend. XXVIII, 182; Instit. 1849, 42; Dingl. Pol. J. CXI, 446.

Wheat  
and  
wheaten  
bran.

dilute sulphuric acid; and sometimes with diastase, he preferred to calculate it from the loss in 100 parts. This method presupposes a knowledge of the weight of all the other constituents, which, however, were only determined in three cases, where the starch amounted to 57.9, 54.4 and 59.7 per cent. In the other cases, sometimes the cellulose, sometimes the ashes, and sometimes both, are left undetermined, in consequence of which, numbers, even as high as 66.7 per cent, were obtained for the starch.—From the bran, Pélégot (in four analyses) obtained from 7 to 9.3, as a mean 8.0 per cent of cellulose.

E. Millon(1) has likewise endeavoured to determine the amount of cellulose in wheat, with especial reference to the separation of the bran. Whilst Boussingault fixes the amount of cellulose in wheat at 7.5 per cent, Millon, whose result coincides with that of Pélégot, only finds between 1.25 and 2.38 per cent.—Millon succeeded in extracting considerable quantities of glutinous substances from the bran with acetic acid and alcohol; he found in 100 parts, starch, dextrin and sugar 50.0; sugar 1.0, gluten 14.9, fat 3.6, cellulose 9.7, salts 5.7, water 13.9, the remaining 1.2 per cent consists, according to Millon, of adhering resinous and odorous matters. In an abstract(2) published before the rest of the investigation, he gave 53.0 per cent of starch, dextrin and sugar, and 0.5 per cent of salts, with the same numbers which were given afterwards for the other substances, and considered the 3.4 per cent still wanting, as incrusting and odorous matters; in another statement(3) published soon after the preceding, he gave 5.0 per cent as the amount of salts.

Millon is of opinion that the nutritive power of the wheat (as Fürstenberg has already shown) is diminished by the separation of the bran in greater proportion than it is increased by the removal of the cellulose, whence it becomes a point of economy entirely to omit the process of sifting. He defends this opinion (which is not acquiesced in by Pélégot)(4), but without bringing forward any important original views.

**Testing of Wheaten Flour.**—Le Canu(5) has indicated methods for the detection of the adulterations of wheaten-meal.—The recognition of potato-starch depends upon the process of washing recommended by Boland, and upon the observation of Payen, that wheat- and potato-starch exhibit different reactions with solution of potassa. After washing the gluten from the dough prepared with the meal under examination, the milky liquid is poured through a silk sieve

(1) Ann. Ch. Phys. [3] XXVI, 5; J. Pr. Chem. XLVII, 167 (in abstr.)

(2) Compt. Rend. XXVIII, 37; Instit. 1849, 28; Dingl. Pol. J. CXI, 386.

(3) Compt. Rend. XXVIII, 264; Dingl. Pol. J. CXII, 142.

(4) See p. 489.

(5) J. Pharm. [3] XV, 241; Dingl. Pol. J. CXIII, 55.

into a conical pointed glass, and allowed to stand for some time. The potato-starch subsides first, and is thus concentrated in the point of the vessel; the water and the upper layer being poured off, the remainder is placed in a watch-glass, covered with 30 parts of solution of potassa of 1.75 per cent, and examined under the microscope. The granules of potato-starch swell to 6 times their volume, and form a jelly, whilst the wheaten starch remains unaltered.

Testing of  
wheaten-  
flour.

The method proposed by Le Canu for detecting admixtures of the flour of the leguminosæ is not a formal method of testing, but merely a qualitative chemical analysis for legumin, combined with a microscopic investigation of the very indefinite appearances of the starch and cellular tissue of the leguminosæ.

**Chicory-coffee.**—A. Chevallier(1) makes use of the property possessed by the seeds of wheat and the leguminosæ, as well as by bread and acorns, of striking a blue colour with iodine, in consequence of the starch which they contain, for the detection of fraudulent additions of these substances to chicory-coffee; he likewise recommends for the same purpose the reaction of the decoctions of acorns and leguminous plants with sulphate of sesquioxide of iron, with which they produce a black precipitate.

**Sugar-refining.**—As early as the year 1810 Proust recommended the employment of sulphite of lime to prevent the fermentation which so rapidly takes place in the juice of the sugar-cane; in 1829 Dubrunfaut took out a patent for the sulphurisation of the juice of beetroot previously to its purification, by the addition of sulphurous acid or of its acid salts; a similar patent was taken out by Stolle in 1838, to dispense with bone-charcoal in the sugar-refineries, by employing bisulphite of lime, the addition of which, however, must be preceded by the usual purification with hydrate of lime.—More recently, Melsens(2) has resumed the investigation of this subject. He started with the principle that the great loss in the sugar-manufacture is only to be avoided by the introduction of a substance which shall prevent the conversion of the albuminous matters of the juice into ferments, and thus render the fermentation of the juice impossible. Of the substances which may be employed for this purpose, bisulphite of lime appears to him the most appropriate. He therefore instituted a series of experiments upon its practical application. The propositions which Melsens has based upon these experiments have been introduced into the world by Dumas (and subsequently by the Minister Lanjuinais) in such a manner as to allow us to expect a radical reform in the existing process, and a consequent increase of the produce, on which account, these statements created such unusual sen-

(1) J. Pharm. [3] XVI, 50; J. Chim. Méd. 1849, 276; Dingl. Pol. J. CXII, 387.

(2) Ann. Ch. Phys. [3] XXVII, 273; Rev. Scientif. Industr. XXXVI, 276; J. Pr. Chem. XLIX, 76; Dingl. Pol. J. CXIV, 375, 411; Ann. Ch. Pharm. LXXII, 101.

Sugar-  
refining.

sation until the details of the process were published.—The following are the most important of Melsens' results :

The bisulphite of lime produces scarcely any, or no change, in cane-sugar, when in contact with the air, if it be not added in larger quantity than is necessary to prevent the production of a ferment ; an excess of bisulphite, however, affects the sugar, especially on ebullition. The sulphuric acid produced by oxidation of the sulphurous acid is rendered harmless, since it immediately enters into combination with lime. At a temperature of  $100^{\circ}$ , bisulphite of lime separates albumin and casein almost entirely from yolk of egg, milk and blood ; if sugar be dissolved in these liquids, about 93 per cent may be extracted unchanged from the filtrate. The bisulphite of lime therefore acts, not only by preventing the fermentation, but also as a powerful purifier.—The colouring matters existing in the juice of the beetroot and sugar-cane are masked, but not fully destroyed, by this salt ; it entirely and permanently prevents, however, the coloration of the juices of these plants by exposure to the air. With regard to the mode in which the bisulphite should be employed, Melsens found that the juice of the crushed sugar-cane, immediately mixed with 1 per cent of a solution of the lime-salt of  $10^{\circ}$  B., purified by boiling, and filtered, furnished, by gradual crystallisation, large hard crystals of sugar-candy with the slightest traces of decomposed sugar. Sugar-canes of different kinds, and degrees of maturity, even when partly exhausted, and afterwards washed with a weak solution of this salt, behaved in the same manner. Melsens believes, that since, in the application of his method, no fear of fermentation need be entertained, the evaporation of the saccharine liquid by artificial heat may be replaced by a process of gradation by the heat of the sun.—In beetroot, there were much greater difficulties to contend with, especially since the evil consequences of the presence of a large amount of salts cannot be avoided by Melsens' process ; the inventor, however, believes that an addition of bisulphite of lime to the expressed marc will ensure a complete exhaustion by means of systematic washing ; he proposes to increase the nutritive power of the exhausted residue by mixing it (previously to its use as food) with molasses, and thus to restore the salts of the latter to the soil in the excrements of the animals. Melsens believes, that by the addition of bisulphite of lime to the crushed beet, and washing with a solution of this salt, the molasses produced may be so far diminished that, probably, only  $\frac{1}{10}$  of crystallisable sugar will be lost in the refining ; and that, at all events, 8 per cent of "*bonne quatrième*" would be gained. He thinks, lastly, that if advantage be taken of the purifying properties of the bisulphite of lime, the employment of bone-black (except for the whitest kinds of sugar) may be omitted ; (it is well known that the price of the sugar depends chiefly upon the bone-black.) In several experiments,

crushed beet, treated according to his method, furnished, by gradual evaporation, a moist crystalline mass, which gave the same quantity of cane-sugar as indicated in the juice, when examined by the polarising apparatus. This was the case with beetroot, differing in age, colour, ripeness and soundness, but the products were never so fine as those obtained from the sugar-cane. All the experiments of Melsens were conducted in the laboratory, and therefore, on the small scale. On this account he refrains from laying down for the manufacturers any definite plan of operation, and only states decisively, that the addition of bisulphite of lime must precede all the other operations upon the crushed beet, and that the disadvantages of the process of the so-called gradual crystallisation, which was given up long ago, may, by the addition of this substance, be avoided, and the process in question, on account of its many advantages, again be brought into use. The anticipated cheapness and simplicity of this process, lose somewhat, however, from two circumstances which Melsens has by no means under-valued. In the first place, the sugar thus prepared retains a sulphurous taste, from which it can be freed only by long washing (which occasions a loss of 10 per cent), or else by a protracted exposure of the powdered loaf to the air, or to an atmosphere of ammonia (which is stated to confer a flavour of vanilla). Secondly, it is questionable whether the residue of the beet, after treatment with sulphite of lime, is still fit for food. According to Melsens' experience in the refinery of Claes, at Lembeek, where sulphurous acid is employed, it appears that the exhausted beet, which has thus been treated, may be eaten by animals.

Stolle, in a separate treatise, has laid claim to priority in the invention of the process proposed by Melsens.—Payen(1) confirms the statement, that the crystallised product, and also the molasses obtained by the process of Melsens are nearly colourless, but adds, that this want of colour is by no means to be regarded as an indication of purity. He found, indeed, that the crystals contained certain viscous nitrogenised matters, together with a substance, which, under the influence of the atmosphere and of traces of ammonia, assumed, first a rose, and afterwards a wine-red tint. In 1000 parts of the juice of beetroot, it is said that there are 50 parts of foreign matters to be separated; when lime and bone-black are employed, at most, 20 parts of these foreign matters remain, in Melsens' process (according to Payen's experiments, which were not more precisely stated) 45 parts are left behind. It hence appears, in Payen's opinion, advisable to retain the bone-black, and perhaps also the purification with lime, although the advantage of the method proposed by Melsens for preventing the fermentation, cannot be disputed.

(1) Monit. Industr. 1850, 1415; Dingl. Pol. J. CXV, 212.



Sugar-  
refining.

Lüdersdorff (1) believes, that for the treatment of the juice of beet, any acid is preferable to sulphurous acid, or its acid salts, if it can afterwards be more easily removed than this acid. Since, according to his view, the juice of beetroot contains some substances which are only to be separated by acids, and others only by alkalies, he proposes, to mix the juice first with sulphuric acid, to separate the milky liquid by decantation (which cannot be effected in less than twelve hours, even with the help of an addition of plastic clay, which Lüdersdorff recommends), and afterwards to purify by means of lime. It will be seen, that this process does not differ essentially from that of Achard and Kodweiss.

Scoffern (2) states, that the process of purification mentioned in the Annual Report for 1847 and 1848, II, p. 344 has been put to the test during twelve months on the large scale, and not only effects a saving of time and labour, but allows of the purification of the crudest products, and renders the use of bone-black unnecessary.

With regard to saccharimetry, see pp. 85 and 419.

**Potato-Disease.**—Lelieur (3) believes that the diminution and exhaustion of the tubers by the growth of many shoots during the period of their laying in store, are the causes of the potato-disease. With regard to his process for ensuring the healthy growth of these plants, we must refer to the original treatise.

Respecting the potato-disease, see also p. 480.

**Poppy-seeds.**—Sacc (4) has communicated an extended analysis of the seeds of the white poppy (*Pavot blanc, var. à yeux ouverts*) from a brown clayey calcareous soil, 90 meters above the level of the Lake of Geneva. The seeds were very clean and white, and were obtained from a thriving crop of the year 1838. The examination was divided into the estimation of the proximate organic constituents, the ultimate analysis of the seeds, and the analysis of their ashes.—Since, from their toughness, the seeds could not be finely pulverised, Sacc found it better to express the oil; this was effected in a wedge-press with 24 kilogrms. of substance, the first time in the cold, the second time with water of 30°. He thus obtained 43.75 per cent of oil, 53.22 of oil-cake, and 3.03 of water as loss. 100 parts of the oil-cake thus obtained, when dried at 100° in a stream of carbonic acid (to avoid the oxidation of the oil which it still presents) gave 84.0 of dry substance; in this process, a small indeterminable quantity of a substance possessing a faint odour was volatilised, together with the water. When exhausted with ether, the dried oil-cake left 76.24 per cent of residue; from the ethereal solution 17.31 of fat was ob-

(1) Dingl. Pol. J. CXIV, 145.

(2) Chem. Gaz. 1849, 403; Instit. 1849, 316.

(3) Compt. Rend. XXVIII, 263; Dingl. Pol. J. CXII, 386.

(4) Ann. Ch. Phys. [3] XXVII, 473; J. Pr. Chem. XLIX, 296.

tained; Sacc considers the 6.45 parts of dry oil-cake still wanting, as volatile oil, without explaining how this can exist in the oil-cake after drying at 100°.—In the ethereal solution, Sacc sought in vain for the organic bases contained in opium. The residue left, after treating the oil-cake with ether, contains, according to Sacc, a pectin-compound similar to bassorin, woody fibre, casein, and albumin. He endeavoured to estimate these by dissolving the pectin-compound out of the oil-cake by digestion with very dilute sulphuric acid, extracting the fat and the protein-compounds from the residue by means of a weak solution of soda, and calculating the residue as woody fibre. Disregarding the hygroscopic moisture, which amounted to 3.03 per cent (Sacc here leaves out of consideration the water remaining behind in the oil-cake), the poppy-seeds contain 45.1166 per cent of fatty oil, directly determined, 9.4979 of fatty oil together with colouring and odorous matters, extracted by ether, 3.545 of volatile matter, 23.2636 of pectin-compounds, 12.6448 of protein-compounds, 5.9321 of woody fibre. In spite of the four places of decimals calculated by Sacc, these determinations must necessarily be only approximative.

Sacc moreover determined the ultimate composition of the seeds, the oil-cake and oil; he dried these substances at 100° in a stream of carbonic acid. The seeds thus lost 6.86 per cent of water, to expel which it was necessary to dry them during fourteen days. By combustion of the dried substance with chromate of lead, estimation of the nitrogen by Will and Varrentrapp's method, and determination of the ash as usual, he obtained the following results; for the seeds (I), for the oil-cake (II), for the same after exhausting with ether (III), and for the oil filtered with exclusion of air (IV).

	I.	II.	III.	IV.
Carbon . . .	62.23	47.74	42.27	76.63
Hydrogen . . .	9.20	6.76	6.04	11.63
Nitrogen . . .	3.59	5.97	7.64	—
Oxygen and loss .	17.97	28.94	30.85	11.74
Ash . . .	7.00	10.59	13.20	—

Respecting the composition of the ash of poppy-seeds, see p. 483.

Sacc has endeavoured, from the estimation of the proximate constituents and the determination of their ultimate composition, to infer the ultimate composition of the seeds and of the oil-cake, and compared the results of this calculation with those given in I, II, and III. He here forgets, however, that the estimation of the proximate constituents gives no satisfactory account of the deficiency of more than 3 per cent, which he ascribes to some hypothetical volatile odorous substance, moreover, that the other substances were not weighed in the pure state, that they still retained part of the ashes of

Poppy-seeds.

the seeds, and, in short, that he is not in possession of accurate data for such a calculation. Nothing, therefore, can be less surprising, than that great discrepancies should be perceived, to the extent of several per cent, between the calculated results and those obtained by experiment. Thus, for example, the amount of nitrogen found in the seeds was 3.59, that calculated, only 1.72 per cent; the oil-cake exhibits similar deviations. Sacc sees in this difference a confirmation of the view, that the nitrogen exists in poppy-seeds, not only in the form of protein-compounds, but also of ammonia and amidogen-compounds, and finds another support for this view in the circumstance that the poppy-seeds evolve ammonia when triturated with caustic soda.

**Oil-cake as Food for Cattle.**—A circumstance known by experience to all agriculturists, is the excessive variation in the nutritive power of different specimens of oil-cake from the same kind of seed. T. Way(1) has therefore performed a series of chemical analyses to determine the question, whether this difference in value depends upon chemical causes, upon different amounts of albuminous substances, upon the presence of different quantities of water or sand, or lastly, upon other conditions, such as easy and difficult digestibility, and the like. The examination extends to the amount of water, of ash, of albuminous substances and fat. The amount of nitrogen (determined by Will and Varrentrapp's process) is taken as the measure of the albuminous substances; the fat was determined by exhausting with ether. In thirty-three experiments with different linseed-oil cakes (Table M, Nos. 1 to 33 inclusive), the amount of albuminous substances varied from less than 25 to above 36 per cent; in twenty-one experiments, it varied between 28.3 and 31.5. The amount of these constituents does not vary, as the oil certainly does, according to the origin of the material. If we look back to the composition of the seeds (Nos. 34 to 40 inclusive, Table M), differences are observed in the amount of nitrogen, which perfectly correspond to those in the oil-cake; the results of Way's experiments farther showed, that the predominating opinion respecting a fraudulent addition of sand, &c., has no foundation. The oil-cake from rape-seed appears to be richer in nitrogen, which, however, does not depend upon the greater abundance of this substance in the rape-seed (No. 43 of Table M).

**Various kinds of Food for Cattle.**—Estimations similar to the above, in peas and beans (Nos. 44 to 49 inclusive), have been conducted under Way's direction, by Ward and Eggar, (Nos. 50 to 55 inclusive, of Table M). Their results confirm the close correspondence in the composition of the two seeds, as well as their high nutritive power.

TABLE M.

Numbers corre- sponding to Table E.			In the fresh substance.						
			Nitrogen per cent.	Fat per cent.	Ash per cent.	Water per cent.			
T. Way.	LINSEED OIL-CAKES.								
	France	.	.	.	No. 1	4.58	9.77	21.62	6.96
	"	.	.	.	" 2	3.98	7.45	22.66	7.48
	"	from Dunkirk	.	.	" 3	4.63	10.12	8.72	7.20
	"	from Treport	.	.	" 4	4.72	10.16	7.61	7.32
	"	from Bordeaux	.	.	" 5	4.61	9.99	8.08	8.16
	"	from Marseilles	.	.	" 6	4.59	9.67	8.02	7.50
	"	"	.	.	" 7	4.96	8.40	7.25	7.85
	"	"	.	.	" 8	5.72	7.89	7.66	8.31
	American	.	.	.	" 9	4.58	13.04	6.49	7.63
	"	.	.	.	" 10	4.10	13.57	7.56	9.51
	"	.	.	.	" 11	5.25	10.71	5.76	6.56
	"	.	.	.	" 12	4.63	11.49	5.67	7.53
	"	.	.	.	" 13	4.91	7.45	6.04	8.81
	"	.	.	.	" 14	4.85	11.51	7.15	7.06
	"	New Orleans	.	.	" 15	4.85	12.11	5.78	6.09
	English	.	.	.	" 16	3.92	16.55	6.18	8.23
	"	.	.	.	" 17	4.23	13.43	6.92	8.66
	"	.	.	.	" 18	4.99	13.88	6.90	8.83
	"	.	.	.	" 19	5.08	13.34	8.04	9.38
	"	.	.	.	" 20	4.90	14.33	7.54	8.10
	"	.	.	.	" 21	4.51	10.05	6.94	9.25
	"	.	.	.	" 22	3.93	16.10	5.45	10.26
	"	from Russian seed	.	.	" 23	4.29	11.28	9.63	7.20
	"	.	.	.	" 24	4.62	15.32	6.04	7.51
	"	.	.	.	" 25	5.00	11.83	8.67	8.84
	"	.	.	.	" 26	5.28	11.89	6.21	8.92
	"	.	.	.	" 27	4.84	10.62	9.05	7.54
	"	.	.	.	" 28	4.85	8.58	8.54	8.11
	"	.	.	.	" 29	4.26	10.33	11.11	8.29
	"	.	.	.	" 30	4.82	12.34	8.37	8.77
	"	.	.	.	" 31	5.35	11.32	6.74	9.29
	"	.	.	.	" 32	4.40	6.60	8.53	8.97
"	.	.	.	" 33	5.04	7.00	7.51	9.96	
145 146	LINSEED.								
	From Riga	.	.	.	" 34	3.60	34.70	5.25	9.45
	From Memel	.	.	.	" 35	3.33	36.00	3.56	8.74
	From the Black Sea	.	.	.	" 36	3.31	38.42	5.64	10.12
	English of 1847	.	.	.	" 37	4.60	36.66	2.68	12.33
	"	.	.	.	" 38	5.28	32.77	3.30	11.00
	"	.	.	.	" 39	4.25	33.50	4.08	10.58
	"	.	.	.	" 40	4.29	38.11	4.03	8.57
	"	.	.	.	" 41	5.23	11.63	5.70	7.06
	"	.	.	.	" 42	5.58	10.62	10.41	6.62
147 148	RAPE OIL-CAKES.								
	Unknown	.	.	.	" 41	5.23	11.63	5.70	7.06
	"	.	.	.	" 42	5.58	10.62	10.41	6.62
	RAPE-SEED.								
	Dwarf rape	.	.	.	" 43	4.21	37.84	3.31	6.44
	PEAS.								
	White peas	.	.	.	" 44	3.98	—	—	13.60
	Produce thereof on clayey soil	.	.	.	" 45	3.57	1.01	—	15.40
	"	"	"	sandy soil	" 46	2.97	—	—	13.60
	Grey peas	.	.	.	" 47	3.08	1.56	—	14.60
Produce thereof on clayey soil	.	.	.	" 48	3.47	1.54	—	16.60	
"	"	"	sandy soil	" 49	3.28	1.04	—	16.40	
144	BEANS.								
	Heligoland or tick-beans	.	.	.	" 50	3.57	1.15	—	13.20
	Produce thereof on clayey soil	.	.	.	" 51	2.81	1.25	—	14.20
	"	"	"	sandy soil	" 52	3.40	1.53	—	15.80
	Mazagan beans	.	.	.	" 53	2.36	1.47	—	17.00
	Produce thereof on clayey soil	.	.	.	" 54	3.19	—	—	11.00
	"	"	"	sandy soil	" 55	3.49	1.71	—	16.50
	Clover-hay	.	.	.	" 56	1.87	—	—	15.60
	Wheat-chaff	.	.	.	" 57	0.68	—	—	12.90
	Potatoes	.	.	.	" 58	0.34	—	—	75.80
Henneberg.	Sweet turnips	.	.	.	" 59	0.23	—	—	83.00
	Beet	.	.	.	" 60	0.28	—	—	87.25
	Red turnips	.	.	.	" 61	0.18	—	—	83.90
	Yellow turnips	.	.	.	" 62	0.15	—	—	87.60

TABLE N.

Articles of food.	Water p. c.	Ash of the substance		Nitrogen in the substance			Fat in the substance	
		nor- mal	dry	nor- mal	dry	free from ash	nor- mal	dry
		p. c.	p. c.	p. c.	p. c.	p. c.		
Egg (entire ?)	74.67	—	5.29	2.18	8.62	9.10	10.43	40.00
Root of Psoralea esculenta	—	1.67	—	0.63	—	—	—	—
Strasburg beer (containing 0.04 alcohol)	—	—	3.93	0.81	—	—	—	—
Entire beet root	—	—	6.08	—	1.11	—	—	—
American wheat (imported in 1847)	—	2.62	—	2.26	—	—	—	—
Plums (flesh of)	12.99	—	5.21	0.73	6.00	6.30	—	—
Cultivated chesnuts	54.21	—	4.04	0.53	1.17	1.21	—	—
Wild chesnuts	48.06	—	3.20	0.50	0.96	0.99	—	—
Bread from Mettray	"	—	—	—	1.67	—	—	—
Igname from India (fresh)	79.64	1.11	5.50	0.29	1.46	1.54	—	—
" lower part	"	—	9.06	—	2.53	2.77	—	—
Linseed	7.11	3.93	4.24	3.09	3.33	3.47	38.00	—
Figs (from the market)	21.43	—	4.37	0.94	1.21	1.26	—	—
Ammunition bread (from the bakery on the Quai de Billy)	41.07	—	1.40	1.22	2.07	2.09	—	—
Ordinary Parisian bread	41.21	—	1.43	1.25	2.13	2.15	—	—
White cabbage (choux pommés)	89.87	—	10.89	—	2.42	2.72	—	—
Meal from American wheat (imported 1847)	11.05	—	—	—	2.10	—	1.16	—
" " Indian igname.	15.50	—	3.60	1.00	1.19	1.23	—	—
" " Indian sweet potatoes	12.77	—	2.20	0.67	0.76	0.78	—	—
Cheese from Brie	53.99	5.63	12.08	2.39	5.11	5.85	24.83	53.29
" " Neufchatel	61.87	4.25	11.17	2.28	5.99	6.07	18.74	49.15
" " Marolles	40.07	5.93	9.91	3.73	6.24	6.92	28.73	47.95
" " Roquefort	26.53	4.45	6.06	5.07	6.91	7.35	32.31	43.99
" " Holland	41.41	6.21	10.61	4.10	7.01	7.84	25.06	42.78
" " Gruyeres	32.05	4.79	7.05	5.40	7.96	8.56	28.10	41.81
" " Chester	30.39	4.78	6.88	5.56	8.00	8.59	25.18	36.61
" Parmesano	30.31	7.09	10.18	5.48	7.87	8.76	21.68	31.12

Kinds of fodder.	Water p. c.	Ash p. c. in the		Nitrogen p. c. in the		Chloride of sodium.	
		nor- mal	dry	nor- mal	dry	p. c. in the ash.	p. c. in the dry substance.
substance.		substance.					
Hay from St. Gilles (saline soil)	13.00	7.99	9.19	1.49	1.73	32.86	3.02
" " Orange, May (no saline soil)	13.05	8.44	9.71	1.39	1.19	14.93	1.45
" " " July (no saline soil)	13.08	8.57	9.86	1.49	1.72	15.82	1.56
" " " October (saline soil)	14.00	8.29	9.65	1.70	1.98	12.74	1.23
Straw (from a saline soil)	11.00	6.09	6.85	—	—	14.59	1.00
" (from an ordinary soil)	10.00	3.99	4.44	—	—	14.18	0.63

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TABLE O.

Origin of the Coals.	Numbers.	100 parts by weight of the dry fuel.							Specific gravity.
		contain :					leave :		
		Car- bon.	Hydro- gen.	Nitro- gen.	Sul- phur.	Oxy- gen.	Ash.	Coke.	
WELSH COALS.									
Thoma's Merthyr . . . . .	1	90.12	4.33	1.00	0.85	2.02	1.68	86.53	1.30
Nixon's Merthyr . . . . .	2	90.27	4.12	0.63	1.20	2.53	1.25	79.11	1.31
Hill's Plymouth Works . . . . .	3	88.49	4.00	0.46	0.84	3.82	2.39	82.25	1.35
Aberdare and Co.'s Merthyr . . . . .	4	88.28	4.24	1.66	0.91	1.65	3.26	85.83	1.31
Gadley Nine-foot Seam . . . . .	5	86.18	4.31	1.09	0.87	2.21	5.34	86.54	1.33
Nenth Abbey . . . . .	6	89.04	5.05	1.07	1.60	—	3.55	61.42	1.31
Gadley Four-foot Seam . . . . .	7	88.56	4.79	0.88	1.21	—	4.88	88.23	1.32
Llynvi . . . . .	8	87.18	5.06	0.86	1.33	2.53	3.04	72.94	1.28
Rock Vawr . . . . .	9	77.98	4.39	0.57	0.96	8.55	7.55	62.50	1.29
LANCASHIRE COALS.									
Balcarres Arley . . . . .	10	83.54	5.24	0.98	1.05	5.87	3.42	62.89	1.26
Blackley Hurst . . . . .	11	82.01	5.55	1.68	1.43	5.28	4.05	57.84	1.26
Blackbrook Little Delf . . . . .	12	82.70	5.55	1.48	1.07	4.89	4.31	58.48	1.26
Rushy Park Mine . . . . .	13	72.76	5.23	1.32	1.01	8.90	5.69	56.66	1.28
Blackbrook Rushy Park . . . . .	14	81.16	5.99	1.35	1.62	7.20	2.68	59.10	1.27
Johnson and Wirthington's Rushy Park . . . . .	15	79.50	5.15	1.21	2.71	9.24	2.19	57.52	1.28
Laffak Rushy Park . . . . .	16	80.47	5.72	1.27	1.39	8.33	2.82	56.26	1.35
Balcarres Haigh Yard . . . . .	17	82.26	5.47	1.25	1.48	5.64	3.90	66.09	1.28
Wigan, cannel coal . . . . .	18	79.23	6.08	1.18	1.43	7.24	4.84	60.33	1.23
Balcarres Lindsay . . . . .	19	83.90	5.66	1.40	1.51	5.53	2.00	57.85	1.26
Balcarres Five Feet . . . . .	20	74.21	5.03	0.77	2.09	8.69	9.21	55.90	1.26
Johnson and Wirthington's Sir John . . . . .	21	72.86	4.98	1.07	1.54	8.15	11.40	56.15	1.31
NEWCASTLE COALS.									
Andrew's House, Tansid . . . . .	22	85.58	5.31	1.26	1.22	4.39	2.14	65.13	1.26
Newcastle Hartley . . . . .	23	81.81	5.50	1.28	1.69	2.58	7.14	64.61	1.29
Hedley's Hartley . . . . .	24	80.26	5.24	1.16	1.78	2.40	9.12	72.31	1.31
Bate's West Hartley . . . . .	25	80.61	5.26	1.52	1.85	6.51	4.25	—	2.26
Buddle's West Hartley . . . . .	26	80.75	5.04	1.46	1.04	7.86	3.85	—	1.23
Hastings Hartley . . . . .	27	82.24	5.42	1.61	1.35	6.44	2.94	35.60	1.25
Carr's Hartley . . . . .	28	79.83	5.11	1.17	0.82	7.86	5.21	60.63	1.25
Davison's West Hartley . . . . .	29	83.26	5.31	1.72	1.38	2.50	5.84	59.49	1.25
North Percy, Hartley . . . . .	30	80.03	5.08	0.98	0.78	9.91	3.22	57.18	1.25
Haswell Coal Company's steamboat Wallend . . . . .	31	83.71	5.30	1.06	1.21	2.79	5.93	61.38	1.27
Derwentwater's Hartley . . . . .	32	78.01	4.74	1.84	1.37	10.31	3.73	54.83	1.26
Original Hartley . . . . .	33	81.18	5.56	0.72	1.44	8.03	3.07	58.22	1.25
Cowpen and Sidney, Hartley . . . . .	34	82.20	5.10	1.69	0.71	7.97	2.33	58.59	1.26
SCOTCH COALS.									
Wellewood . . . . .	35	81.36	6.28	1.53	1.57	6.37	2.89	59.15	1.27
Eglinton . . . . .	36	80.08	6.50	1.55	1.38	8.05	2.44	54.94	1.25
Stuvelly . . . . .	37	79.85	4.84	1.23	0.72	1.96	2.40	57.86	1.27
FOREIGN COALS.									
Conception Bay, Chili . . . . .	38	70.55	5.76	0.95	1.98	13.24	7.52	43.63	1.29
Sidney, New South Wales . . . . .	39	82.39	5.32	1.23	0.70	8.32	2.04	—	—
Port Famine . . . . .	40	64.18	5.33	0.50	1.03	22.75	6.21	—	—
Chirique . . . . .	41	38.98	4.01	0.58	6.14	13.38	36.91	—	—
Laredo Bay . . . . .	42	58.67	5.52	0.71	1.14	17.33	16.63	—	—
Landy Bay, 1., Patagonian . . . . .	43	62.25	5.05	0.63	1.13	17.54	13.40	—	—
" " 2., " . . . . .	44	59.63	5.68	0.64	0.96	17.45	15.64	—	—
Talcabano Bay . . . . .	45	70.71	6.44	1.08	0.94	13.95	6.92	—	—
Vancouver's Island . . . . .	46	66.93	5.32	1.02	2.20	8.70	15.83	—	—
Colcurra Bay, Chili . . . . .	47	78.30	5.50	1.09	1.06	8.37	5.68	—	—
Artificial Fuel, Lyon's . . . . .	48	86.36	4.56	1.06	1.29	2.07	4.66	—	1.13
Brown coal, from Wildshut . . . . .	49	53.79	4.26	—	0.98	25.39	15.58	54.7	1.306
" " " Thallern . . . . .	50	49.58	3.84	—	4.56	22.68	19.34	63.7	1.413
" " " Gloggnitz . . . . .	51	57.71	4.49	—	3.12	22.14	12.54	54.4	1.364
Bituminous coal, from Grünbach . . . . .	52	69.66	4.29	—	1.71	17.42	6.92	60.9	1.320

TABLE P.

Origin of the anthracite.	Numbers.	I.	II.	III.	IV.	V.	VI.	VII.
Anthracite from Wales	1	10.16	10.72	15.33	53.0	82.29	57.5	538.48
	2	9.96	10.70	15.44	51.7	82.29	64.5	514.93
	3	9.75	10.18	15.84	51.2	84.78	64.0	499.20
	4	9.73	10.27	15.86	49.3	81.73	74.5	479.68
	5	9.56	10.46	15.88	54.8	83.16	76.0	523.88
	6	9.38	9.65	14.51	59.3	83.57	50.0	556.23
	7	9.29	10.73	15.92	51.6	82.79	68.5	479.36
	8	9.19	9.58	14.99	53.3	80.35	—	429.82
	9	7.68	7.88	13.15	55.0	80.21	65.5	422.40
Anthracite from Lancashire	10	8.83	9.09	13.67	50.5	78.17	76.0	455.91
	11	8.81	9.00	13.75	48.0	78.90	65.0	422.88
	12	8.29	8.55	13.33	51.0	78.16	61.5	422.79
	13	8.08	8.35	13.48	47.0	80.04	67.0	379.76
	14	8.02	8.26	14.12	55.3	80.15	80.5	443.50
	15	8.01	8.16	13.44	50.0	80.10	69.0	400.50
	16	7.98	8.16	12.79	52.6	84.07	75.5	419.74
	17	7.90	8.23	13.09	50.8	80.10	80.0	401.32
	18	7.70	8.06	13.83	48.3	76.80	95.0	371.91
	19	7.44	7.58	12.18	51.1	78.61	70.0	380.18
	20	7.21	7.35	12.07	49.0	79.11	44.5	353.29
Anthracite from Newcastle	21	6.32	6.62	11.07	51.6	81.73	82.0	326.11
	22	9.39	9.80	14.44	52.1	78.86	—	489.21
	23	8.23	8.66	14.81	50.5	80.27	78.5	415.61
	24	8.16	8.71	14.12	52.0	81.79	85.5	424.32
	25	8.04	8.26	13.45	50.8	78.17	69.5	408.43
	26	7.82	8.01	13.73	50.6	77.11	80.0	395.69
	27	7.77	7.96	13.34	48.5	78.04	75.5	376.84
	28	7.71	8.13	14.37	47.8	78.23	77.5	368.53
	29	7.61	7.83	14.01	47.7	78.36	76.5	362.99
	30	7.57	7.72	13.53	49.1	78.29	60.0	371.68
	31	7.48	7.85	13.39	49.5	79.36	79.5	370.66
	32	7.42	7.66	13.53	50.4	78.79	63.5	373.96
	33	6.82	6.98	12.38	49.1	77.98	80.0	334.86
	34	6.79	7.02	13.33	47.9	78.67	74.0	325.24
Anthracite from Scotland	35	8.24	8.39	13.20	52.6	79.78	80.0	433.42
	36	7.37	7.48	11.31	52.0	79.84	79.5	483.24
	37	7.26	7.40	13.06	49.9	79.79	88.5	362.27
Anthracite from Conception Bay	38	5.72	5.96	11.91	—	80.54	—	—
Lyon's artificial fuel	39	9.58	9.77	14.59	61.1	74.73	—	585.33

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Henneberg(1) estimated the water and nitrogen in different kinds of food (Nos. 56 to 62 of Table M).

With regard to the amount of nitrogen contained in cabbage and carrots, see p. 384, and with regard to nutrition, see p. 365.

Payen(2) published the results of his analyses of different nutritive matters and species of food in a synopsis which we give in Table N.

Various  
kinds of  
food for  
cattle.

**Fuel and Illuminating Materials. Coal.**—L. Playfair and de la Beche(3) have continued their former researches upon the value of coal as fuel for steam-navigation, with the same apparatus and the same methods which they formerly employed. The ultimate analyses from 1 to 48 in Table O were conducted partly by How, partly by T. T. Phillips. The Roman characters in Table P bear the same signification as in the preceding Annual Report, II, p. 355; VI, however, does not indicate (as was erroneously stated in the previous Annual Report) the diminution by attrition, but the amount of large coal which remained out of 100 parts after the diminution from this cause had been deducted. J. A. Phillips(4), induced by a statement made by Vaux, with regard to the presence of copper and lead in coal, tested 16 specimens without finding even a trace of either of these metals.

**Brown-coal.**—The Academy of Sciences at Vienna has undertaken an investigation of the brown and anthracite coals of Austria, which in the general mode of proceeding closely resembles that just described. The first communication upon this subject by Schrötter(5) treats of four fossils belonging to the brown-coal formation, Nos. 49 to 52 of Table O. The amount of nitrogen present was not separately determined, and is, therefore, calculated with the oxygen; the specific gravities were determined with the powdered substance, the quantity of coke by gradual carbonisation. By rapid carbonisation, from 2 to 3 per cent less coke was always obtained. In addition to the data in Table O, the following were also determined: A, the cohesion in the sense in which it is taken by Playfair and de la Beche, estimated from the percentage of coal which remained behind upon a sieve of one square inch meshes after treatment in a rolling cask; B, size (expressed in pounds) of the masses in which the coal comes into the market; C, percentage of water which it loses at

(1) Loc. cit. p. 365.

(2) J. Pharm. [3] XVI, 279.

(3) From the Civil Engineer's and Architect's Journal, Sept. 1849, 269, in *Diagl. Pol. J.* CXIV, 345.

(4) *Chem. Soc. Qu. J.* II, 1.

(5) *Wien. Acad. Ber.* 1849, November and December, 240.



Brown-coal.

100°, and D, that which the dried coal again absorbs in 24 hours; E, the heating power in units of heat calculated from the elementary composition; F, that calculated from the test with oxychloride of lead; G, heating power of the coke determined as at F; H, sp. gr. of the coal in masses, estimated after covering with wax; I, amount of sulphur present in the coke.

	A.	B.	C.	D.	E.	F.	G.	H.	I.
Brown coal from Wildshut	77.0	1 to 80	26.1	18.8	4421	3621	5339	1.269	1.58
" " Thallern	70.5	50 " 100	22.5	12.7	3969	3498	4631	1.327	5.93
" " Gloggnitz	72.0	1 " 2	25.1	15.9	4813	4054	5295	1.346	3.23
Bituminous coal from Grünbach	58.5	1 " 40	6.6	6.6	5878	4933	6377	1.303	1.97

Barruel(1) has examined a specimen of lignite found in boring a well at Villette near Paris, which is thought to be closely connected with that of Bièvre and Yonne in the basin of the Seine. The upper and lower portions of the seam consist of a clay penetrated by carbonaceous matter; the true seam begins at a depth of 73 meters, and possesses a thickness of 1.5 meters. A specimen of this lignite containing sulphide of iron furnished 51.3 per cent of volatile matter, 33.8 of coal, and 14.9 of ash consisting of lime, sesquioxide of iron, alumina and silica.

Wackenroder(2) and, under his direction, Staffel, have examined a peculiar earthy brown coal which covers, to a thickness varying from half a foot to two feet, the upper part of a seam, from 4 to 12 feet in thickness, of ordinary brown coal, containing, however, much steatite, at Gerstewitz, in the neighbourhood of Merseburg. This upper portion consists of a homogeneous, yellowish-brown, brittle mass resembling dry loam, of sp. gr. 1.1297, which is scarcely moistened by water in consequence of the presence of a considerable amount of a waxy fat soluble in hot alcohol and ether. Dried at 100° it lost 22 per cent of water. The dry mass, incinerated in a platinum crucible, left 45.41 per cent of ash, and when exhausted with carbonate of soda, the filtered solution gave with hydrochloric acid 22.6 per cent of a brown precipitate, which Wackenroder considers as humic acid. Although the extraction of the fat, by treatment of the dry substance with successive portions of alcohol (of 84 per cent) and ether, was not quite perfect, 17.9 per cent of fat were thus obtained.

The analysis of the ashes, according to Wackenroder's method(3), gave in 100 parts:

(1) Compt. Rend. XXIX, 237; Instit. 1849, 273.

(2) Arch. Pharm. [2] LX, 14; partly in Ann. Ch. Pharm. LXXII, 315.

(3) Annual Report for 1847 and 1848, II, 240.

Lime . . . . .	0·16
Sulphate of lime . . . . .	1·14
Phosphate of lime . . . . .	0·09
Chloride of calcium . . . . .	trace
Portion soluble in water . . . . .	1·39

Sesquioxide of iron . . . . .	1·97
Alumina . . . . .	0·66
Proto-sesquioxide of manganese . . . . .	0·38
Carbonate of lime . . . . .	10·21
Magnesia . . . . .	2·56
Silica . . . . .	6·71
Sand . . . . .	73·57
Portion insoluble in water . . . . .	96·06

Brown-coal.

thus amounting in all to 97·45 per cent, leaving a deficiency of 2·55 per cent.—The ultimate analysis of the waxy fat, designated by Wackenroder *cerinin*, gave, in four experiments, 76·68 to 78·24 per cent of carbon, and 11·09 to 12·27 of hydrogen. From this want of concordance in the results of analysis, and from the failure of an attempt to determine the equivalent, some more accurate evidence in support of the formula  $C_{20}H_{19}O_2$  proposed by Wackenroder is desirable.

**Economy of Heat.**—With regard to the arrangements for heating, and their theory, Marozcau(1) has communicated some remarks and results, for which we must refer to the journal quoted below.

**Illuminating Material from Peat.**—Reece(2) has discovered a process, which has not yet been published, for obtaining from peat, by means of dry distillation, a material (paraffin?) for candles similar to spermaceti, and he believes it to be applicable on the large scale. In an experiment, 1000 parts of Irish peat are said to have yielded, amongst other products, 11 parts of carbonate of ammonia, and somewhat less than 3 parts of this illuminating material which would be less costly, by somewhat more than one half, than spermaceti.

#### Fibres of Plants. Detection of the Fibres of *Phormium tenax*.

—Payen(3) has tested Vincent's process for recognising the fibres of *Phormium tenax* in any fabric (compare II, p. 358, of the preceding Annual Report). He finds that the reaction is not produced by the fibre itself, but merely by some adhering matters which are peculiar to the different plants. It does not succeed, therefore, with well-cleansed and bleached stuffs; but since those fabrics used on ship-board, for which Vincent's test is designed, are not included in this category, Payen found the method in question quite adequate to its object.

(1) Instit. 1849, 321. Morin's report thereupon, Compt. Rend. XXX, 758; Instit. 1850, 211.

(2) Times, 28th of July, 1849; Dingl. Pol. J. CXIII, 237, 317.

(3) Compt. Rend. XXIX, 491; Instit. 1849, 353; Monit. Industr. 1849, No. 1397; Dingl. Pol. J. CXV, 150.

Cotton  
which  
cannot  
be  
coloured.

**Cotton which cannot be coloured.**—W. Crum(1) has investigated the circumstance often observed, that fibres are present in cotton fabrics which remain white, even when the rest of the stuff has been thoroughly dyed. This unalterable cotton (dead cotton, *coton mort*) is found scattered in small quantities between the ordinary cotton, and forms finely interwoven flocks of a high silky lustre. These flocks consist of short fibres of slight tenacity, which, according to Crum, when examined under the microscope, differ from ordinary cotton in possessing no spiral structure, and especially in not being hollow and tubular, but solid throughout. Crum considers that all cotton-fibre, before it ripens, contains a sap which, if dried, fills up the cavity of the fibre. If, in consequence of the withering of the seed, or any similar cause, any of the cotton does not ripen, these fibres will not become coloured, or, at least, not permanently coloured, because they possess no empty cavity which can take up the colouring matter. In this he finds an important support for his theory that this coloration is, in all cases, a mechanical process, which operates either by a similar filling up of cavities, or by surface-attraction analogous to the action of charcoal in decolorising.

**Dyeing. Safflower.**—Salvétat(2) has examined 8 specimens of safflower reputed of good quality, and has found notable differences in their percentage composition.

No.	1.	2.	3.	4.	5.	6.	7.	8.
Water*	6.0	11.5	4.5	4.8	6.0	8.0	11.1	6.0
Albumin	3.8	4.0	8.0	1.7	4.0	4.0	1.5	3.0
Yellow colouring matter, a†	27.0	30.0	30.0	26.1	26.0	20.0	21.0	26.0
" " " b	3.0	4.0	6.0	2.1	4.2	6.1	4.4	5.0
Extractive matter	5.0	4.4	6.0	4.1	3.6	4.0	6.5	5.4
Waxy matter	1.0	0.8	1.2	1.5	0.7	0.6	0.6	0.8
Carthamin	0.5	0.4	0.4	0.6	0.3	0.4	0.3	0.1
Woody fibre	50.4	41.77	38.4	56.0	49.4	16.7	50.1	50.0
Silica	2.0	1.5	3.5	1.0	4.0	8.4	1.2	1.6
Sesquioxide of iron and alumina	0.6	0.8	1.6	0.5	1.0	1.6	0.4	0.5
Sesquioxide of manganese.	0.1	0.1	0.3	—	0.5	0.1	—	0.1

\* Which is expelled at 20°.

† With soluble sulphates.

**Yellow Colouring Matter in Buck-wheat.**—C. Nachtigal(3) points out that the straw of buck-wheat contains a yellow colouring matter applicable to the dyeing of cotton. This colouring matter, however, is said to be far less abundant than that in luteolin and quercitrin, and

(1) Phil. Mag. [3] XXXV, 334; Dingl. Pol. J. CXV, 145; J. Pr. Chem. L, 122.

(2) Ann. Ch. Phys. [3] XXV, 339; J. Pr. Chem. XLVI, 477; Dingl. Pol. J. CXII, 78; J. Pharm. [3] XV, 271.

(3) Verh. Gew. Bef. Pr. 1849, 123; Dingl. Pol. J. CXV, 157.

to be accompanied by tannin and extractive matters, which render it somewhat dingy; nevertheless, experiments with 60 pieces of calico steeped in acetate of alumina did not prove unsatisfactory.

With regard to the action of light on prussian-blue, see p. 198; for the indigo-test of Reinsch, see p. 423; and for farther information on the subject of colouring matters, p. 314, *et seq.*

**Mordants.**—J. A. Carteron(1) has taken out a patent for four new prescriptions for tartaric acid mordants for different kinds of red, brown and black.

**Bleaching of Gum.**—H. Picciotto(2) has taken out a patent for two methods of bleaching gum-arabic. By the first process, the bleaching of the dissolved gum is effected by means of sulphurous acid; according to the second process, with freshly precipitated hydrate of alumina. For the necessary manipulations we must refer to the specification.

**Chinese Nut-galls.**—W. Stein(3) has examined a new species of nut-gall from China. It comes into the market in the form of nodulated, hollow masses covered with a grey felt-like substance; they vary from  $\frac{1}{10}$  of an inch to an inch in diameter, and contain the dead brood of the insect to which they owed their origin upon the parent tree (according to Reichenbach, a *Solanum*). Beneath the felt, the substance itself is reddish, shining, and brittle; its fracture has a greasy vitreous lustre, and it emits an odour of tobacco; it cakes together when warmed, and if strongly heated, leaves a difficultly combustible coal, which gives 2 per cent of ash (lime, magnesia, potassa, iron, phosphoric acid, silica, carbonic acid and chlorine). It becomes soft and leathery in boiling water and alcohol, and evolves an odour of tannin. The analysis, the mode of effecting which is not specified, gave 69 per cent of quercitannin, 4 of other kinds of tannin not farther investigated, 1 of saponifiable fat, 8 of starch, 5 of woody fibre, and 13 of water. This new drug contains, therefore,  $1\frac{3}{4}$  times as much tannin as the galls of Aleppo, and is, moreover  $\frac{1}{5}$  cheaper.

Yellow  
colouring  
matter in  
buck-  
wheat.

(1) Chem. Gaz. 1849, 368.

(2) Lond. Journ. of Arts, 1849, 112; Chem. Gaz. 1849, 147; Dingl. Pol. J. CXII, 68.

(3) From the Polyt. Centr. 1849, Lief. 22, in Dingl. Pol. J. CXIV, 433.

# MINERALOGY.

**Generalities. Views of Mineral Species.**—Kobell (1) has defended his views regarding the species of minerals with isomorphous constituents, against the objections raised by Fuchs(2); and has sought to establish them more completely.

We cannot here go farther into the subject of this discussion, as the most essential part of it is already contained in Kobell's first treatise(3).

Respecting the different kinds of *lustre*, consult p. 70.

**Metalloids. Amorphous Diamond.**—The mineral collection of the *Ecole des Mines*, in Paris, received some time since from Hofmann, the dealer in minerals, some specimens (among them one of 65·76 grms. weight) of a brownish-black mineral from Brazil, which for some time had been made use of for polishing diamonds. Upon examination Rivot(4) found it to consist of compact diamond. The form it affects is that of an angular, but somewhat worn and rolled pebble; it presents under a lens, on its surface, minute, irregular, iridescent laminae, with fine interstices between them, which give to it here and there a striped appearance, like that of many specimens of obsidian.—The degree of hardness Rivot found to be greater than that of topaz, and the sp. gr.=3·012; 3·141; 3·416 and 3·255. By the combustion of it in oxygen gas in Dumas' apparatus there was obtained:

	Sp. gr.	Ash.	Carbon.	Sum.
I.	3·141	2·03	96·84	98·87
II.	3·416	0·24	99·73	99·97
III.	3·251	0·27	99·10	99·37

In analysis I. some carbonic acid was lost. The yellowish ash which in I. preserved the form of the specimen experimented on, appeared under the microscope to consist of a ferruginous clay and small transparent crystals, which could not be more closely deter-

(1) J. Pr. Chem. XLVI, 494; Rammelsberg's Handwörterb. 4. Suppl., 38 (in abstr.)

(2) See Annual Report for 1847 and 1848, II, 381.

(3) See *ibid*.

(4) Ann. Min. [4] XIV, 423; Compt. Rend. XXVIII, 317; Instit. 1849, 73; J. Pr. Chem. XLVII, 460; Phil. Mag. [3] XXXIV, 397.

mined.—According to Marignac,(1) this compact diamond has been used in the manufactories of Geneva and Neuchâtel ever since 1847.

**Metals. Gold.**—Native gold from California has been analysed by T. H. Henry(2) (analysis I a. I b., and II.); by E. T. Teschemacher(3) (analysis III a. and b.); by Oswald, of Oels(4) (analysis IV a. and b.); by Rivot(5) (anal. V., VI., VII. and VIII.); and by A. W. Hofmann(6) (anal. IX.)

Metals  
Gold.

Sp. gr.	I a.	I b.	II.	III a.	III b.	IV a.	IV b.	V.	VI.	VII.	VIII.	IX.
	15.96	—	15.63	16.33	—	17.40	—	15.70	16.65	17.55	16.23	—
Au . . .	88.75	90.12	86.57	90.33	93.00	87.6	90.96	90.9	91.4	89.1	93.0	89.61
Ag . . .	8.88	9.01	12.33	6.80	7.00	8.7	9.04	8.7	8.5	10.5	6.7	10.05
Cu . . .	0.85	0.87	0.29	—	—	—	—	—	—	—	—	—
Fe . . .	trace	—	0.54	—	—	—	—	0.2	trace	0.2	trace	—
Fe <sub>2</sub> O <sub>3</sub> . .	—	—	—	1.00	—	—	—	—	—	—	—	—
Sandy residue	1.40	—	—	0.66	—	3.7	—	—	—	—	—	—
Sum . . .	99.88	100.00	99.73	98.79	100.00	100.0	100.00	99.8	99.9	99.8	99.7	99.66

The columns I b., III b. and IV b. contain the results of analyses I a. III a. and IV a., calculated for percentage composition, after deducting the amount of mechanically admixed substances.

According to C. Grant(7), in October, 1848, a sudden and impetuous storm of rain, which fell in Sarawak (Borneo), washed down from the Trian Mountain a vast mass of soil, in which gold was found in grains, and sometimes in lumps 3 to 4 bunkals(8) in weight, and, indeed in such quantity, that of some 2000 workmen who were employed in the search for the gold, each is said to have obtained at least a bunkal per month.

**Argentiferous Gold.**—Lévol(9) has communicated the following results of some analyses of native argentiferous gold, which he had completed some time before: I. Gold dust; II. Gold scales from the Senegal; III. Gold dust from North Brazil; IV. Gold grains from California; V. Gold grains from the Senegal; V. Gold grains from an unmentioned locality.

	I.	II.	III.	IV.	V.	VI.
Au . .	84.5	86.8	91.0	92.7	94.00	98.3
Ag . .	15.3	11.3	8.7	6.9	5.85	1.7
Cu . .	0.2	0.9	0.3	0.4	—	—
Pt . .	—	—	—	—	0.15	—
	100.0	99.0	100.0	100.0	100.00	100.0

(1) Arch. Ph. Nat. XI, 56.

(2) Phil. Mag. [3] XXXIV, 205; J. Pr. Chem. XLVI, 405 (in abstr.); Ann. Min. [4] XV, 89.

(3) Chem. Soc. Qu. J. II, 193.

(4) Pogg. Ann. LXXVIII, 96.

(5) Ann. Min. [4] XVI, 127.

(6) Ann. Ch. Pharm. LXX, 255.

(7) From the Journal of the Indian Archipelago, Oct. 1849, in Chem. Gaz. 1850, 71.

(8) A bunkal of Sumatra = 48, of Singapore = 54 grms.

(9) Ann. Ch. Phys. [3] XXVII, 310; J. Pr. Chem. XLIX, 171.

Argentiferous  
gold.

Levol inclines to the opinion that gold and silver occur combined together in definite though not very often in simple proportions.—The first of his analyses agree with the tolerably simple proportions  $\text{Au}_6\text{Ag}$ ;  $\text{Au}_8\text{Ag}$ ;  $\text{Au}_{12}\text{Ag}$ .

**Copper.**—In the sitting of the *Académie des Sciences* of Feb. 5, 1849, Cordier(1) called attention to a specimen of native copper from Lake Superior of 50 kilogrammes weight, which, together with another ten times as heavy, belonged to a cargo of American copper that had arrived at Havre. According to Cordier, the rock through which the copper on Lake Superior is disseminated minutely, or occurs in gangues with calc-spar, datolite and epidote, is a wacke like that of Oberstein, produced from augite-porphry.—According to a letter from C. Jackson(2) to Silliman a lump of native copper of nearly 50 tons weight was found in the Cliff Mine, on the Eagle River.(3)

**Tellurides. Telluride of Silver.**—Rammelsberg(4) has analysed granular telluride of silver covered with a green incrustation, from Retzbanya.

Ag.	Te.	Foreign matter.	Total.
64.67	27.96	15.25	97.88

A compact variety contained 60.28 per cent of silver.

**Tetradymite. (Telluride of Bismuth.)**—Coleman Fisher(5) has analysed the tetradymite of the White Hall Mine, Spotsylvania, in Virginia. It consists of slightly-soiling inelastic folia of a metallic lustre, colour between lead- and steel-gray, and hardness=2. On charcoal before the blow-pipe it melts readily, colours the flame blue, and gives the odour of selenium, yielding at the same time a white incrustation with a red border. The analysis gave :

Te.	Se.	Bi.	Fe.	$\text{SiO}_2$ .	Total.
35.77	6.81	51.65	1.25	3.86	99.34

The mineral is accordingly tetradymite, in which one portion of tellurium is replaced by selenium instead of by sulphur.(6) Its formula is  $\text{Bi Se}_3 + 3(\text{Bi Te}_3)$ .

**Arsenides. Copper-nickel.**—Suckow(7) has analysed copper-nickel from Richelsdorf (I), and Schnabel(8) that from Rohnard Mine, near Olpe, in Westphalia (II).

	S.	As.	Ni.	Fe.	Cu.	Total.
I.	0.15	53.69	45.76	2.70	—	102.30
II.	0.48	52.71	45.37	—	1.44	100.00

(1) Compt. Rend. XXVIII, 161.

(2) Sill. Am. J. [2] VII, 286.

(3) See Annual Report for 1847 and 1848, II, 384.

(4) Rammelsberg's Handwörterbuch, 4. Suppl., 220.

(5) Sill. Am. J. [2] VII, 282.

(6) See Annual Report for 1847 and 1848, II, 385.

(7) Suckow, Verwitterung im Mineralreich, I. Heft, 58.

(8) Rammelsberg's Handw., 4. Suppl., 122.

**Arsenide of Nickel. (White Nickel-ore.)**—Rammelsberg(1) found the composition of an arsenide of nickel of sp. gr. 6·411, from Allemont, to be as follows :

Arsenide  
of nickel.  
(White  
nickel-  
ore.)

Ni.	Fe.	As.	S.	Total.
18·71	6·82	71·11	2·29	98·93

**Arsenide of Silver.**—Rammelsberg(2) has also analysed the arsenide of silver from the Samson Mine, near Andreasberg, of which he found the sp. gr. to be = 7·473.

	S.	As.	Sb.	Ag.	Fe.	Total
I.	0·85	49·19	15·46	8·88	24·60	98·89
II.	—	—	—	8·81	21·33	—
III.	1·10	—	15·43	8·24	—	—

The same chemist considers this mineral, which most mineralogists take to be a mere mixture, to be a real mineral species, on account of its homogeneous appearance and its constant amount of silver, of which the formula would be = (Ag, Fe) As, or = (Fe S<sub>2</sub> + Fe As) + 5 (5Fe<sub>4</sub>As<sub>3</sub> + Ag<sub>2</sub>Sb<sub>3</sub>).

**Arsenical Pyrites. Glaucodote.**—Breithaupt(3) called an arsenical pyrite, from Huasco, in Chili, which was distinguished by a high proportion of cobalt, as well as by a distinct cleavage in the direction OP, glaucodote. [Arsenical pyrites, containing cobalt, are already known by the analyses of Scheerer, Wöhler and Hayes.(4)] The mineral occurs in combinations of the form  $\infty P$  and of  $OP$ , or of  $\infty P$  and  $\frac{1}{3} \bar{P}\infty$ , where  $\infty P$  measures  $112^{\circ} 36'$  in the brachydiagonal principal section. The colour is dark tin-white. The streak is black. The hardness = 7 (= 5·5 of Mohs) and the sp. gr. = 5·975 to 6·003. —The analysis performed by Plattner gave as the result :

S.	As.	Co.	Ni.	Fe.	SiO <sub>3</sub> .	Total.
20·210	43·200	21·774	trace	11·900	trace	100·084

According to which, this mineral has the composition of cobaltine, which it resembles also in this, that if heated at the end of a sealed glass tube, it gives only a trace of arsenic. Its formula is (Co, Fe)As + (Co, Fe) S<sub>2</sub>, and as the equivalents of cobalt and iron in it stand in the relation = 2 : 1, it may be considered as a combination of 2 equivalents of cobaltine with 1 equivalent of arsenical pyrites. It may also be considered as cobaltine of the same crystalline form as the arsenical ore. Breithaupt and Rammelsberg actually consider cobaltine to be dimorphous.

(1) Rammelsberg's Handw., 4. Suppl., 8.

(2) Pogg. Ann. LXXVII, 262; Rammelsberg's Handwörterb., 4. Suppl., 9 (in abstr.)

(3) Pogg. Ann. LXXVII, 127; Rammelsberg's Handwörterb., 4. Suppl., 73 (in abstr.)

(4) See Rammelsberg's Handw. I, 46.



Cobaltine.

**Cobaltine.**—Schnabel(1) analysed an ore from the Grüne Löwe Mine, near Siegen, which before had been called by the name of *fibrous smaltine* (I), besides compact "*scheidkobalt*" (II), from the Morgenröthe Mine, near Siegen, which had also formerly been taken for smaltine. Ebbinghaus(1) analysed, under Rammelsberg's direction, cobaltine from Scuterud (III).

	S.	As.	Sb.	Co.	Fe.	Quartz.	Total.
I.	19.98	42.53	2.84	8.67	25.98	—	100.00
II.	19.35	45.31	—	33.71	1.62	—	99.99
III.	20.25	42.97	—	32.07	3.42	1.63	100.34

**Nickel-Glance.**—Crystallised nickel-glance from the Jungfer Mine, near Müsen, has, according to Schnabel,(2) the following composition :

S.	As.	Ni.	Fe.	Total.
18.94	46.02	32.66	2.38	100.00

**Tombazite.**—Kennigott(3) observed in tombazite, from Ilobenstein, which is a combination of the cube with the octahedron, so great a distortion in the direction of an axis of the octahedron, that a crystal of it appeared as a tetragonal prism with the faces P. He found, however, that the angle of P : P measured over the solid angle =  $70^{\circ} 11'$ , therefore, nearly =  $70^{\circ} 32'$ .

**Sulphides.** "**Bleischweif.**"—Rammelsberg(4) analysed the bleischweif from the Bockswiese, near Clausthal. Its sp. gr. = 7.532 to 7.557.

PbS.	ZnS.	FeS.	SbS <sub>3</sub> .	Total.
95.85	3.34	0.54	0.30	100.03

Selenium, which had been recorded by former analysts, was not present as a constituent. The sulphide of zinc seemed, according to Rammelsberg, to be interspersed as zinc-blende.

**Copper-Glance.**—Schnabel(5) analysed a massive copper-glance from the Neue Hart Mine, near Siegen.

S.	Cu.	Fe.	SiO <sub>3</sub> .	Total.
21.50	74.73	1.26	2.00	99.49

**Nickel Pyrites. (Millerite.)**—Millerite from the Friedrichszeche, near Oberlahr, in the district of Altenkirchen, contains, according to Schnabel(6), 35.03 per cent sulphur, and 64.80 per cent nickel.

(1) Rammelsberg's Handwörterbuch, 4. Suppl., 116 and 117.

(2) Ibid., 163.

(3) Kennigott's Mineralog. Untersuch., 1. Heft, 71.

(4) Rammelsberg's Handwörterbuch, 4. Suppl., 24.

(5) Ibid., 121.

(6) Ibid., 89.

**Cinnabar.**—Schnabel(1) also analysed the crystallised cinnabar from the Merkur Mine, near Silberg, in Westphalia (I), as well as the crystalline laminated cinnabar of Königsberg, near Hohensolms, in the district of Wetzlar (II).

Cinnabar.

	S.	Hg.	Matrix.	Total.
I.	13.67	86.79	—	100.46
II. a.	13.78	84.55	1.02	99.35
II. b.	13.70	—	—	—

**Iron Pyrites.**—Schnabel(2) analysed, moreover, amorphous iron pyrites from the Philipphoffnung Mine, near Siegen (I), and the same crystallised, from Heinrichslegen, near Müsen (II).

	Fe.	S.	Total.
I.	46.53	53.39	99.92
II.	46.50	53.59	100.00

A specimen of iron pyrites from the Silberkaule Mine, near Eckerhagen, in the district of Waldbroel, contained 0.168 per cent nickel.

Plattner(3) analysed, at Breithaupt's suggestion, a great number of iron pyrites of a dark colour, in search of arsenic, and found therein sometimes as much as 1 per cent of it. It is particularly the pyrites which occur in veins with sulphate of baryta and fluor-spar which contain the arsenic. The sulphide of arsenic is deposited, when the mineral is heated in a glass tube, below the sulphur, and just above the assay.—Iron pyrites from older gangue-formations, or newer rock-formations, contain seldom, if ever, any arsenic.

According to Allain and Bartenbach(4), the pyrites from Chessy and St. Bel, near Lyons, contain at least 0.0001 of gold. (See p. 441).

**Louehidite. (Marcasite.)**—Breithaupt(5) gives the name of louehidite to a mineral found near Freiberg, Schneeberg and in Cornwall, of 4.925 to 5.001 sp. gr., which, by its lustre, colour, and streak, resembles arsenical pyrites, but coincides with marcasite in its crystalline form, twin-crystals and angles. The angle of  $\tilde{P} \infty$  Breithaupt found to be  $= 79^\circ 14'$ , that of  $\infty P = 104^\circ 24'$ , both measured in the brachydiagonal principal section. An analysis performed by Plattner gave:

S.	As.	Fe.	Co.	Cu.	Pb.	Total.
49.612	4.396	44.225	0.354	0.749	0.204	99.540

(1) Rammelsberg's Handwörterbuch, 4. Suppl., 269.

(2) Ibid., 198.

(3) Pogg. Ann. LXXVII, 141.

(4) Compt. Rend. XXIX, 152, 700, 784.

(5) Pogg. Ann. LXXVII, 135; Rammelsberg's Handw., Suppl., 211 (in abstr.)

Lonchidite.  
(Marcasite.)

Plattner considers this mineral as a combination of marcasite with  $\frac{1}{2}$  of an equivalent of arsenical pyrites. Rammelsberg sees in it nothing but a mixture of isomorphous minerals: ( $\infty$ P of marcasite is  $=106^{\circ} 36'$ ,  $\infty$ P of arsenical pyrites  $=111^{\circ} 53'$ ; see p. 11).

**Bismuth-nickel.** — Schnabel(1) analysed distinctly crystalline bismuth-nickel from the Grönaue Mine, near Schutzbach, in the county of Sayn-Altenkirchen.

	S.	Bi.	Ni.	Co.	Cu.	Fe.	Pb.	Total.
I.	31.99	10.49	22.03	11.24	11.59	5.55	7.11	100.00
II.	33.10	10.41	22.78	11.73	11.56	6.06	4.36	100.00

These analyses explain the chemical constitution of this mineral as little as that performed by Kobell(2), from which they differ greatly.

**Sulphide of Cobalt. (Sulphide of Nickel and Cobalt.)** — According to a new analysis performed by Schnabel (I) of the well-known beautiful sulphide of cobalt from the Jungfer Mine, near Müsen, formerly analysed by Wernekinck(3), and according to an analysis performed by Ebbinghaus (II) of the same ore, from the Schwaben Mine, near Müsen, this mineral contains *nickel*, and more of it than of cobalt; Rammelsberg(4) therefore gives it the name of cobalt-nickel pyrites.

	Sp. gr.	S.	Ni.	Co.	Fe.	Total.
I.	4.8	41.98	33.64	22.09	2.29	100.00
II.	5.0	42.30	42.64	11.00	4.69	100.63

Both analyses confirm the correctness of Frankenheim's formula  $RS + R_2S_3$ .

**Antimony-Glance.** — The crystallised antimony glance from the Casparizeche, near Arnsberg, in Westphalia, contains, according to Schnabel(5) 27.85 per cent sulphur, 72.02 per cent antimony, and 0.13 per cent iron.

**Heteromorphite. (Plumose Antimony Ore.)** — Plumose antimony, which was lately met with near Wolfsberg, in the Harz, in compact masses(6), has now been found also in a fibrous state in the Herzog-Alexius-Erbstollen, near Mägdesprung, on which account Rammelsberg and Zincken have proposed, instead of the former name, which merely referred to the capillary-formed variety, the name heteromorphite for the species(7). — According to Zincken, the fibrous variety has evidently, like jamesonite, a rectangular cleavage in the

(1) Rammelsberg's Handw., 4. Suppl., 164 (in abstr.)

(2) J. Pr. Chem. VI, 332.

(3) Schweigger's Journ. IX, 306.

(4) Rammelsberg's Handw., 4. Suppl., 117.

(5) Ibid., 87.

(6) Annual Report for 1847 and 1848, II, 389.

(7) Pogg. Ann. LXXVII, 240; Rammelsberg's Handw., 4. Suppl. 95 (in abstr.)

direction of the length of the fibres, and is slightly brittle; of a metallic lustre, and light lead-gray colour, and somewhat darker streak. Its degree of hardness = 3, and its sp. gr. = 5.478 to 5.49, in the form of a coarse powder = 5.693 to 5.719 (R). The analysis performed by Rammelsberg, gave :

Hetero-  
morphite.  
(Plumose  
antimony-  
ore.)

	S.	Sb.	Pb.	Fe.	Zn.	Cu.	Total.
I.	20.86	30.67	42.79	2.83	1.84	1.01	100.00
II.	21.35	—	40.47	2.68	5.82	0.50	—

The zinc and iron arise from admixed zincblende and from iron pyrites, and the remainder of the antimony from admixture of antimony glance.

**Bournonite.**—According to Zincken(1), bournonite occurs in the Hartz in the following varieties : (I) In the Meiseberg, in tabular crystals of a semi-metallic lustre, and light lead-grey colour, in which O P is predominant, and which have an uneven, and sometimes splintery fracture ; (II) Near Neudorf, in prismatic crystals of metallic lustre, and dark iron colour, with more decidedly inclined planes, and of a conchoidal fracture ; (III) Near Wolfsberg, in pitch-black rectangular prismatic crystals of metallic lustre, merely composed of the planes  $\infty \bar{P} \infty . \infty \bar{P} \infty . O P$ , and with conchoidal fracture.—Zincken, Rammelsberg, and C. Bromeis, determined the sp. gr. of these varieties, and the two latter have analysed them.

Sp. gr.		I.	II.	III.		
	Zincken	5.703	5.844	5.796		
	Bromeis	{ 5.792	5.822	5.813		
		{ 5.726	5.847	5.855		
	Rammelsberg	5.779	5.863	5.726		
	S.	Sb.	Pb.	Cu.	Total.	
I.	Bromeis	19.487.	24.603	40.421	13.062	97.573
II. a.	Bromeis	20.150	—	41.830	13.180	—
II. b.	Rammelsb.	18.990	24.820	40.036	15.164	99.010
III. a.	Bromeis	19.762	24.340	42.878	13.060	100.040
III. b.	Rammelsb.	19.620	—	41.920	12.380	—

**Bournonite-nickel-glance, and Nickel-bournonite.**—Zincken and Rammelsberg(2) gave the provisional names of bournonite-nickel-glance and nickel-bournonite, to two minerals, which together with iron pyrites and nickel-glance occur in the Antimony Mine, near Wolfsberg, in the Hartz.—The bournonite-nickel-glance (I) has cubic cleavages, but is found also in small cubes. It possesses a metallic lustre, a grey colour, a black streak, and a sp. gr. of 5.635 to 5.706 (R). Its degree of hardness is = 4.5.—Nickel-bournonite (II) has as yet only been found in the amorphous state.

(1) Pogg. Ann. LXXVII, 251 ; Rammelsberg's Handw., 4. Suppl., 26 (in abstr.)

(2) Pogg. Ann. LXXVII, 253.

Bournonite-nickel-glance and nickel-bournonite.

It possesses little lustre, its colour is of a dark lead-gray, bordering on an iron-black. Its fracture uneven, and almost finely granular. Its hardness is = 3·5, and its sp. gr. = 5·524 to 5·592. The analyses were made by means of chlorine.

	S.	Sb.	As.	Ni.	Co.	Pb.	Cu.	Fe.	Total.
I.	16·89	19·53	28·00	27·04	1·60	5·13	1·33	0·51	100·83
II.	19·87	24·28	3·22	5·47	—	35·52	9·06	0·84	98·26

According to Rammelsberg these minerals may be considered either as combinations, or as mixtures of bournonite with nickel-glance. In No. I. the nickel-glance, in No. II. the bournonite, is predominant. The first view is supported by the mineralogical character of the minerals, particularly of No. I., while the results of other analyses, which were made with confessedly impure specimens, and have therefore not been mentioned here, militate against it. Rammelsberg shows, moreover, that these minerals, like bournonite, may be written as combinations of the form  $RS_2$ , viewing sulphur, arsenic, and antimony, as isomorphous(1), as well as that their atomic volumes are nearly equal.

**Gray Copper.**—Weidenbusch(2) has analysed, under H. Rose's direction, "a compact gray copper ore, which was distinguished by a high proportion of mercury, of sp. gr. 5·107, from Schwatz, in the Tyrol (I). Rammelsberg(3) analysed three varieties of gray copper, from Meiseberg, in the Hartz, one of which, (II); of 4·852 sp. gr. was crystallised, while the two others of 4·892 sp. gr., (III), and of 4·526 sp. gr., (IV) were amorphous.

	S.	Sb.	Cu.	Ag.	Zn.	Fe.	Pb.	Hg.	Insol.	Total.
I.	22·96	21·35	34·57	—	1·34	2·24	—	15·57	0·80	98·83
II.	24·80	26·56	30·17	10·48	3·39	3·52	0·78	—	—	100·00
III.	24·22	26·44	31·53	7·27	3·25	4·36	—	—	—	97·07
IV.	24·69	25·74	32·46	7·55	3·00	4·19	—	—	—	97·63

Weidenbusch's analysis shows in the calculation a surplus of 1·87 per cent sulphur, and does not lead to a probable formula.

Rammelsberg's analyses correspond to the known formula  $4RS + SbS_3$ .—With regard to the relation of gray copper to copper pyrites, Rammelsberg and Zincken mention, that there are not only gray copper crystals, *coated* with copper pyrites, but also some which are composed of regularly arranged gray copper and copper pyrites particles, and others which consist of alternate layers. According to their views, therefore, gray copper and copper pyrites in the crystals are of contemporaneous origin, and Volger's opinion

(1) Comp. this Report, p. 10.

(2) Pogg. Ann. LXXVI, 86; J. Pr. Chém. XLVI, 97 (in abstr.); Rammelsberg's Handw., 4. Suppl., 66.

(3) Pogg. Ann. LXXVII, 247; Rammelsb. Handw., 4. Suppl., 65 (in abstr.)

(see the last Annual Report, II, 390) on the pseudomorphous formation of copper pyrites would therefore be erroneous.

Gray  
copper.

According to Gueymard(1) the grey copper from the Chapeau near Champoléon, department des Hautes Alpes, and the bournonite from Saint Arey on the Mure, contain a small amount of platinum, a fact which is said to have been confirmed by Ebelmen.

**Brogniardite.**—Damour(2) designated as brogniardite a mineral of a metallic lustre and an uneven fracture, which gave no indication of a crystalline form, of a black-gray streak, and of 5.950 sp. gr., which had been brought from Mexico by Castelnau. It decrepitates on charcoal, melts easily, and gives off sulphurous acid, fumes of antimony, and an incrustation of oxide of lead. At the end there remains a bead of silver. The analysis of it performed with chlorine-gas gave :

	S.	Sb.	Ag.	Pb.	Cu.	Fe.	Zn.	Total.
I.	19.38	29.95	25.03	24.74	0.54	0.30	0.40	100.34
II.	19.21	29.60	24.46	25.05	0.61	6.36	0.32	99.51
III.	19.14	29.75	24.81	24.94	0.70	0.22	0.37	99.93
Mean	19.24	29.77	24.77	24.91	0.62	0.26	0.36	99.93
Calculation	19.08	30.66	25.65	24.61	—	—	—	100.00

Damour calculates from the mean of these analyses the formula  $PbS + AgS + Sb_2S_3$ , and points out the similarity of this composition with that of the antimonial sulphide of silver according to Wöhler's analysis.

**Red Antimony.**—It is known that Mohs has observed in red antimony the planes  $\infty P \infty$ ;  $0 P$ ;  $P \infty$  and  $2 P \infty$  and  $\alpha = 78^\circ 41'$ , and that he had determined the inclination of  $P \infty$  and  $2 P \infty$  to the principal axis as  $= 34^\circ 6'$ , and  $15^\circ 47'$ . Kenngott(3) has likewise taken measurements of strongly reflecting crystals from Bräunsdorf. He found  $\infty P \infty$ :  $0 P = 102^\circ 9'$ ,  $0 P$ :  $P \infty = 149^\circ 46'$ , which gives  $\alpha = 77^\circ 51'$ , and the inclination of  $P \infty$  to the principal axis  $= 37^\circ 37'$ . Kenngott observed also the hemidome of  $71^\circ 55'$  inclination to the principal axis, according to which it is  $\frac{1}{3} P \infty$ , the angle of which and the principal axis ought to be  $= 70^\circ 41'$ , if we take as a foundation the relation of the axes according to Mohs.

**Anhydrous Oxides. Bismuth Ochre.**—Suckow(4) found in a bismuth ochre from the Fichtelgebirge, derived from needle-ore, 96.5 per cent of teroxide of bismuth, 1.5 per cent of arsenious acid, and 2.0 per cent of hydrated sesquioxide of iron.

(1) Compt. Rend. XXIX, 814.

(2) Ann. Min. [4] XVI, 227; Phil. Mag. [3] XXXVI, 477 (in abstr.)

(3) Mineralogische Untersuchungen, 1. Heft, 1. Breslau, 1849.

(4) Suckow, Verwitterung im Mineralreich, 14; Rammelsb. Handw., 4. Suppl., 261 (in abstr.)

Capillary  
red oxide  
of copper.

**Capillary Red Oxide of Copper.**—According to Kenngott(1) capillary red oxide of copper belongs not to the hexagonal, but to the rhombic prismatic system. He observed in crystals from Nischne-Tagilsk and from Rheinbreitenbach, rhombic prisms with replaced edges, whose planes of truncation were strongly reflecting, and formed angles with one another but little deviating from  $90^\circ$ , while they formed with the weakly reflecting planes of the prism angles of about  $140^\circ$  to  $150^\circ$ . It is known that Suckow observed in capillary red oxide of copper perfect cleavage, following the faces of a rhombohedron of  $99^\circ 15'$  at the terminal edges.—According to this, suboxide of copper would be trimorphous.

**Black Oxide of Copper.**—According to Whitney(2), 40 to 50,000lbs. of pure earthy *compact*, and at the same time *crystalline* oxide of copper has been met with at the Copper Harbour on Lake Superior in North America, and it appears it has all been worked.—The crystals, of which Whitney received some for analysis from Teschemacher, were steel-gray or black cubes with metallic lustre; sometimes with truncated edges, but without cleavage. The hardness was determined to be = 3, and the sp. gr. 6.25.—The earthy mineral acquired a metallic lustre by friction, a pure specimen contained 1.2 per cent silicic acid mixed with it, with traces of carbonate of lime and sesquioxide of iron.

**Rutile.**—In analysing rutile, the locality of which is not given, A. Demoly(3) got the following results:

	TiO <sub>2</sub> .	Fe <sub>2</sub> O <sub>3</sub> .	Mn <sub>2</sub> O <sub>3</sub>	SiO <sub>3</sub>	Total.
I.	96.41	1.63	0.13	1.83	100.00
II.	96.45	1.62	0.14	1.79	100.00
III.	96.43	1.62	0.11	1.84	100.00

**Brookite.**—Romanowsky(4) has discovered brookite in the gold washings from the Atlän in the Ural Mountains, and Hermann has given a description of it. Vertical prisms are predominant in the crystals, which at the utmost are half an inch in length, and  $\frac{1}{4}$  of an inch in width, and the face  $\infty \bar{P} \infty$  (=h' of Levy) occurs but rarely. The measurement gave for P (=e<sup>3</sup> of Levy)  $135^\circ$  in the brachydiagonal principal section,  $101^\circ$  in the macrodiagonal principal section, and  $94^\circ$  in the basal principal section. Besides, for  $\frac{3}{2} \bar{P} \infty$  (=e<sub>2</sub><sup>3</sup>)  $78^\circ$ , for  $\frac{1}{2} \bar{P} \infty$  (=a<sup>2</sup>)  $147^\circ$ , and for  $\infty \bar{P} 2$  (=m of Levy)  $100^\circ 30'$ , all measured in the macrodiagonal principal section. Besides these forms, together with OP, Hermann observed two other

(1) Kenngott, Min. Untersuchungen, 1. Heft, 31.

(2) Proc. Bost. Soc. Nat. Hist., Jan. 1849, 102; Sil. Am. J. [2] VIII, 273.

(3) Demoly, Thèse de Chimie, présentée à la Faculté des Sciences de Besançon; Laur. u. Gerh. C. R., 1849, 325.

(4) J. Pr. Chem. XLVI, 401; Rammelsb. Handw., 4. Suppl., 29 (in abstr.)

vertical prisms,  $\infty \bar{P} n$  of  $137^\circ 30'$ , and  $\infty \bar{P} m$  of about  $161^\circ$ , both likewise measured in the macrodiagonal principal section. According to this,  $n$  would  $=\frac{2}{3}$  and  $m = \frac{2}{3}$ . (Hermann has taken the  $P$  mentioned before as the primary form; but in the drawing he has put the crystals in such a way, that the macrodiagonal has the position of the brachydiagonal, and the face  $\infty \bar{P} \infty$  is in front, as in Levy's drawings.)—The crystals are transparent, purple, and of a metallic adamantine lustre. Their hardness  $=5.5$  to  $6.0$ , and their sp. gr.  $=3.81$ . Analysis gave:

TiO <sub>2</sub> .	Fe <sub>2</sub> O <sub>3</sub> .	Al <sub>2</sub> O <sub>3</sub> .	Loss on ignition.	Total.
94.09	4.50	trace	1.40	99.99

According to Shepard(1), brookite occurs also in the gold-washings of Rutherford County in North America, associated with monazite. He has made measurements of crystals which he received from Clingman, which nearly coincide with those of Hermann, given above.

**Arcansite.**—No mineral has so much occupied mineralogists and chemists in the last year as the arcansite discovered by Shepard(2). Papers on it have been published by Breithaupt(3); W. H. Miller(4), J. Whitney(5), Teschemacher(6), Rammelsberg(7), Damour and Descloizeaux(8), and by Kenngott(9). All of them, with the exception as yet of Breithaupt only, agree that arcansite and brookite belong to one and the same mineral species.

According to Breithaupt, who, like Teschemacher, confirmed Shepard's angular measurements, arcansite crystallises in rhombic octahedra  $P$ , combined with  $2 \bar{P} \infty$ ,  $\infty \bar{P} \infty$ ,  $\bar{P} \infty$ ,  $3 \bar{P} \infty$ ,  $2 P$  and, though more rarely, with  $\frac{1}{2} \bar{P} \infty$ . The faces of  $P$  and  $2 \bar{P} \infty$  are predominant, and give to the crystals the appearance of hexagonal pyramids.—The measurement gave for  $\frac{1}{2} P \infty$ , the facettes of which reflect most perfectly,  $124^\circ 2'$ , in the macrodiagonal principal section; for  $2 \bar{P} \infty$   $79^\circ 41'$ , in the brachydiagonal principal section, and for  $P$ ,  $101^\circ 19'$  to  $23'$ , in the basal principal section.—Breithaupt calculates from this the relation of the principal axis to the macrodiagonal and brachydiagonal  $=1:1.668:0.941$ . The edges of  $P=135^\circ 51'$  in the brachydiagonal principal section,  $95^\circ 20'$  in the macrodiagonal

(1) Sill. Am. J. [2] VIII, 275.

(2) See Annual Report for 1847 and 1848, II, 390.

(3) Pogg. Ann. LXXVII, 302.

(4) Phil. Mag. [3] XXXV, 75.

(5) Proc. Bost. Soc. Nat. Hist. 1849, 42; Sill. Am. J. [2] VII, 433.

(6) Proc. Bost. Soc. Nat. Hist. 1849, 132; Sill. Am. J. [2] VIII, 274.

(7) Pogg. Ann. LXXVII, 586, and Rammelsb. Handw., 4. Suppl., 271.

(8) Ann. Min. [4] XV, 447.

(9) Kenngott's Min. Untersuchungen, 1. Heft, 10 u. 76.



**Arcansite.** principal section, and  $101^{\circ}19'$  in the basal.—For 2 P the same edges are  $=125^{\circ}56'$ ,  $72^{\circ}35'$  and  $135^{\circ}26'$ .— $\infty P$  would be  $=121^{\circ}8'$ ,  $\bar{P}\infty=118^{\circ}8'$ , both taken in the brachydiagonal principal section, and  $\bar{P}\infty=86^{\circ}31'$  in the macrodiagonal principal section.—Its other properties are given by Breithaupt as follows: Cleavage but indistinct in the direction of  $\infty P$ ,  $\infty \bar{P}\infty$ , and P; fracture uneven; hardness,  $=7\frac{1}{4}$  to 8 ( $=5.5$  to  $6.0$  according to Mohs's scale); sp. gr.  $=3.952$ ; colour, iron-black; streak, dark ash-gray; lustre, semi-metallic, bordering on adamantine; opaque.—On account of the chemical similarity of arcansite to brookite, Breithaupt attempted to derive their forms from one another, but failed. He declared therefore both to be different species, and repeated his declaration (1) with particular reference to the cleavage in the direction of a prism of  $104^{\circ}12'$ , a cleavage which is found in brookite, but not in arcansite, at a time when Miller, without giving special reasons, declared both minerals to be identical.—Rammelsberg and Kennigott, however, by comparison of Breithaupt's angular measurements of arcansite with Levy's angular measurements of brookite, and Descloizeaux, by means of a series of his own measurements upon arcansite, have proved that the forms and angles of both minerals really agree with one another. The following table gives a synopsis of the principal angles of arcansite and brookite together with the different determinations of the facettes, in reference to the established position assumed by Breithaupt.

Principal sections.		Arcansite.				Brookite.	
		Shepard.	Breithaupt.	Descloizeaux.	Teschemacher	Levy.	Hermann.
P	brachyd.						
	macrocl.	c	135°15'	135°51'	135°50'	c	135°
	basal	—	95°20'	—	—	e <sup>3</sup>	94°
2 P	brachyd.		101°19'	101°30'	—		101°
	macrocl.		125°56'	—	—		—
	basal	n	72°35'	—	—	b <sup>1</sup>	72° 0'
2 $\bar{P}\infty$	brachyd.		135°26'	136°	—		—
	macrocl.		—	—	—		—
	basal	M	101°	100°19'	100°35'	M	100°
$\frac{1}{2} \bar{P}\infty$	brachyd.		—	—	—		—
	macrocl.	a	123°	124° 2'	123°40'	a	124°
	basal	—	—	—	—	e <sup>1</sup>	123°36'

The sp. gr. of arcansite was found by Whitney  $=4.085$ , by Damour  $=4.030$  and  $4.083$ , by Rammelsberg  $=3.892$  to  $3.949$ .—The latter pointed out that it is nearly equal to that of anatase, and that therefore arcansite might be considered as titanate acid of the form of brookite with the sp. gr. of anatase.—By a careful chemical analysis of the arcansite, Rammelsberg found nothing but titanate acid, and Whitney besides traces only of iron. Damour's analyses gave the following results:

	TiO <sub>2</sub> .	Fe <sub>2</sub> O <sub>3</sub> .	SiO <sub>2</sub> .	Portion not acted upon.	Total.	Arcansite
I.	99.36	1.36	0.73	—	101.45	
II.		96.72	—	6.39	103.11	
III.		101.68	—	1.39	103.07	

(In analysis No. I it was dissolved by melting with bisulphate of potassa, in Nos. II and III with hot sulphuric acid.)—The excess obtained thereby, as well as a small increase of weight of the arcansite whilst being heated either by itself or with sulphuric acid (in which case some sulphurous acid was given off), induced Damour and Descloizeaux to think that a part of the titanium was contained in the arcansite as oxide. They find a support for this opinion in the fact that, according to their experiments, brookite remains unaltered if heated in a glass tube, but takes the lustre and colour of arcansite before the blowpipe in the reducing-flame, and that rutile, if heated in hydrogen-gas, becomes iron-dark, and almost metallic in lustre on being fractured, losing in absolute gravity and gaining in sp. gr. by 0.092. They therefore consider it as not unlikely that arcansite is a brookite which has been altered by heating in the presence of reducing vapours; in this case, however, it ought to have a greater sp. gr. than the brookite, which is quite contrary to truth.

**Red Hematite.**—Schnabel(1) analysed red hematite from the Engelsberg Mine, near Wetzlar (I), from the Hermannszeche in the same place (II), and "Eisenrahm" (III) from the latter mine.

	SiO <sub>2</sub> .	PO <sub>5</sub> .	Fe <sub>2</sub> O <sub>3</sub> .	Al <sub>2</sub> O <sub>3</sub> , CaO, MgO.	HO.	Total.
I.	16.74	0.51	80.95	0.97	0.83	100.00
II.	23.16	0.45	73.77	1.41	1.21	100.00
III.	5.63	0.19	92.45	0.65	1.08	100.00

**Emery.**—L. Smith(2) has laid claim to the discovery of the emery in Asia Minor(3).

**Periclase.**—Damour(4) has analysed periclase repeatedly, with particular reference to the state of oxidation of the iron contained in it. The mineral had been previously purified by a digestion with acetic acid or dilute hydrochloric acid, which do not affect it, from the carbonate of lime and carbonate of magnesia, and from the coating of sesquioxide of iron. In this state it exhibited a distinctly alkaline reaction. Heated with hydrogen, it did not lose in weight. Ignited in oxygen, it increased in weight, so much that all the iron in the mineral must be taken to be protoxide. The sp. gr. Damour found to be = 3.674.

(1) Rammelsb. Handw., 4. Suppl., 194.

(2) Sill. Am. J. [2] VII, 285.

(3) See Annual Report for 1847 and 1848, II, 391.

(4) Bulletin Géolog., [2] VI, 311.

Periclase.

	MgO.	FeO.	Total.
I.	93·86	5·97	99·83
II.	93·38	6·01	99·39

**Iron-Flint.**—The red iron-flint from Sundwich, near Iserlohn, has been analysed by Schnabel(1).

SiO <sub>3</sub> .	Fe <sub>2</sub> O <sub>3</sub> .	Al <sub>2</sub> O <sub>3</sub> .	HO.	Total.
94·93	3·93	0·42	0·73	100·001

**White Antimony.**—Suckow(2) analysed white antimony from Wolfach.

SbO <sub>3</sub> .	Fe <sub>2</sub> O <sub>3</sub> .	SiO <sub>3</sub> .	Sb.	Total.
91·7	1·2	0·8	6·3	100·0

**Hydrated Oxides. Nematite (Brucite).**—According to Whitney(3), the nematite is a fibrous variety of brucite mixed with some carbonate of magnesia. Analysis gave

MgO.	FeO.	CO <sub>2</sub> .	HO.	Total.
62·89	4·65	4·10	28·36	100·00

**Hydrargillite.**—On hydrargillite, see gypsite.

**Brown Hematite.**—Schnabel(4) analysed No. I transparent crystalline laminae of goethite from the Eisenzeche, near Eiserfeld; II. Lepidokrokite from the Huth Mine, near Hamm on the Sieg; III. Long fibrous brown hematite from the same locality; IV. Fibrous brown hematite from Hollerterzug, near Siegen; V. Stilpnosiderite from the Catherina Mine, near Hamm; VI. A black-brown hematite from the Vier Winde Mine, near Hamm(5), produced by oxidation of the iron spar there.

	Fe <sub>2</sub> O <sub>3</sub> .	Mn <sub>2</sub> O <sub>3</sub> .	CaO.	MgO.	HO.	SiO <sub>3</sub> .	PO <sub>3</sub> .	Total.
I.	89·27	0·65	—	—	10·08	—	—	100·00
II.	83·51	4·72	—	—	11·35	0·42	—	100·00
III.	85·57	1·25	—	—	12·63	0·57	—	100·02
IV.	84·24	2·45	—	—	12·68	0·63	—	100·00
V.	75·70	—	—	—	13·32	7·61	2·67	99·30
VI.	76·76	16·56	0·60	0·44	5·64*	—	—	100·00

\* Together with the loss.

**Wad.**—A dark brown wad of 2·179 sp. gr. with reddish-brown streak from Krummau in Bohemia, has, according to Kussin(6), the following composition:

MnO.	O.	Fe <sub>2</sub> O <sub>3</sub> .	HO.	Total.
64·40	7·37	11·12	14·10	96·99

(1) Rammelsb. Handw., 4. Suppl., 193.

(2) Verwitterung im Mineralreich, 1. Heft, 12; Rammelsb. Handw., 4. Suppl., 4 (in abstr.)

(3) Journ. Bost. Soc. Nat. Hist. 1849, 36; Sill. Am. J. [2] VII, 434 (in abstr.)

(4) Rammelsb. Handw., 4. Suppl., 272.

(5) Ibid., 209.

(6) Ibid., 259.

**Oxides  $R_2O_3$  with Oxides RO. (Spinels.) Psilomelane.**—Herter(1) has analysed, under Rammelsberg's direction, compact psilomelane from Elgersburg I, and Heyl, a lamellar psilomelane from Langenberg, near Schwarzenberg, in the Erzgebirge, (II). Another variety equally lamellar from the Junge Sinternzeche Mine, near Eisern, was analysed by Schnabel (III):

Oxides  
 $R_2O_3$   
with  
oxides  
RO.  
(Spinels.)  
Psilome-  
lane.

	MnO.	O.	BaO.	CaO.	MgO.	KO.	CuO.	$Fe_2O_3$ .	HO.	Matrix.	Total.
I.	74.61	16.06	2.40	1.84	0.64	0.92	0.46	—	2.70	—	99.63
II.	68.00	13.62	8.59	0.20	0.53	0.27	0.36	—	3.95	2.18	97.70
III.	78.90	12.02	—	—	—	0.27	—	4.40	4.38	—	99.97

**Coracite.**—Le Conte's coracite(2) has been analysed by Whitney(3). His description of the mineral agrees with that of Le Conte, with the exception of its hardness, which he gives as = 3:

$SiO_3$ .	$Al_2O_3$ .	$Fe_2O_3$ .	$U_2O_3$ .	PbO.	CaO.	$CO_2$ .	HO.	Total.
4.35	0.90	2.24	59.30	5.36	14.44	7.47	4.64	98.70

It is impossible to draw from this any conclusion as to the chemical constitution of the mineral. Whitney thinks that the uranium in the mineral cannot be taken as proto-sesquioxide ( $UO + U_2O_3$ ), as Le Conte has done, because the mineral is easily soluble in hydrochloric acid, while pitchblende cannot be dissolved by it. However, an earthy variety, such as that to which the above analysis seems to apply, might prove, in this respect, different from the hard mineral.

**Irite.**—In a microscopic examination of irite, Kenngott(4) observed distinct crystals of the form of a regular octahedron. They are frequently tabular with two predominant opposite faces, and might, therefore, also be combinations of a rhombohedron with a basal face. The formula  $RO, R_2O_3$  would indicate an octahedron. According to Kenngott, the irite is weakly attracted by the magnet.

**Sapphirine.**—Damour(5) analysed sapphirine. Sp. gr. = 3.473. When pulverised it was fused with bisulphate of potassa.

	$SiO_3$ .	$Al_2O_3$ .	MgO.	FeO.	Total.
I.	14.88	63.31	19.06	2.09	99.34
II.	14.84	63.20	19.50	1.90	99.44

The relation of the oxygen in the MgO to that of  $Al_2O_3$  to that of  $SiO_3$  is, therefore, = 1 : 4 : 1, as also appears from Stromeyer's analysis.

**Hydrated Aluminates. Voelcknerite and Hydrotalcite.**—Hermann(6) is of opinion that voelcknerite(7) described by him, and

(1) Rammelsb. Handw., 4. Suppl., 191.

(2) See Annual Report for 1847 and 1848, II, 396.

(3) Journ. Bost. Soc. Nat. Hist 1849, 36; Sill. Am. J. [2] VII, 434 (in abstr.)

(4) Kenngott's Min. Untersuchungen, 1. Heft, 61.

(5) Bull. Géol. [2] VI, 415.

(6) J. Pr. Chem. XLVI, 237; Rammelsb. Handw., 4. Suppl., 257 (in abstr.)

(7) See Annual Report for 1847 and 1848, II, 397.

Hy-  
drated  
alumi-  
nates.  
Voelckne-  
rite and  
hydrotal-  
cite.

Hochstetter's(1) hydrotalcite, which is similar to it, are produced by decomposition of one and the same mineral, which has obtained different quantities of carbonic acid from the air, and has at the same time lost water in the transition to hydrotalcite. The original composition is said to have been  $= 6 \text{ Mg O, (Al}_2\text{O}_3, \text{Fe}_2\text{O}_3) + 16 \text{ HO}$ .

**Silicates.**—Laurent(2) has given a detailed account of his views of the atomic constitution of the silicates(3). As to his opinions developed there with regard to the relation of composition and crystalline form, see p. 12.

**Anhydrous Silicates. Staurolite.**—Kennigott(4) has measured a staurolite-crystal of good reflecting character from Cheronice. It gave  $\infty P = 128^\circ 57'$  in the brachydiagonal principal section;  $0 P : \bar{P} \infty = 125^\circ 36'$ ,  $\infty P : \infty \bar{P} \infty = 115^\circ 39'$  and  $\bar{P} \infty : \infty P = 137^\circ 18'$  on both sides. From the two last angles to which Kennigott gives preference, it follows  $\infty P = 128^\circ 42'$  and  $\bar{P} \infty = 70^\circ 46'$  in the macrodiagonal principal section, which gives the relation of the principal axis to the macrodiagonal and brachydiagonal  $= 0.676 : 1 : 0.480$ .

According to Kennigott, the composition-face of the known twin-like combinations of staurolite with disthene, is in the former parallel to the brachydiagonal, in the latter parallel to the orthodiagonal principal section, in which direction it presents the most easy cleavage.

**Chiastolite.**—Chiastolite of peach-blossom red colour, and presenting cleavage following a rhombic prism of  $93^\circ 30'$ , and of 3.10 sp. gr., occurring in mica-slate, in the neighbourhood of Bona, gave in an analysis of E. Renou(5) 36.6 per cent silicic acid and 61.9 per cent of alumina, together with traces of magnesia and iron. It has, therefore, the composition of cyanite:  $3 \text{ Al}_2\text{O}_3, 2 \text{ SiO}_3$ .

**Sillimanite. Bucholite. Fibrolite.**—B. Silliman, jun.,(6) has analysed sillimanite, bucholite, and fibrolite, and become convinced that these minerals agree with disthene in their crystalline form, hardness and chemical composition, and are to be considered as varieties of it. He analysed perfectly crystallised sillimanite, (I) from Chester, in Connecticut, the original locality of the Boven mineral; bucholite from Chester county, in Pennsylvania (II), the locality of the mineral analysed by Thomson, besides bucholite from Brandywine Springs (III) in Delaware; and fibrolite coming from the collection of Count Bournon, (IV).

(1) Berzelius' Jahresber. XXIII, 281.

(2) Laur. and Gerh. C. R. 1849, 276.

(3) See Annual Report for 1847 and 1848, II, 397.

(4) Kennigott's Min. Untersuchungen, I. Heft, 49

(5) Exploration Scientifique de l'Algérie, Paris, 1848, 58; Jahrb. Min. 1849, 92 (in abstr.)

(6) Sill. Am. J. [2] VIII, 386; Phil. Mag. [3] XXXV, 459 (in abstr.); J. Pr. Chem. XLIX, 203.

	SiO <sub>3</sub> .	Al <sub>2</sub> O <sub>3</sub> .	MgO.	MnO.	Total.
I.	37.65	62.41	—	—	100.06
II. a.	34.31	64.43	0.52	trace	99.26
II. b.	35.96	—	—	—	—
III.	36.15	63.52	—	—	99.67
IV.	36.30	62.41	0.70	—	99.41

Sillimanite.  
Bucholite.  
Fibrolite.

Silliman is of opinion that andalusite also has the same composition as disthene, and, therefore, that these minerals are species of the dimorphous silicate of alumina  $3 \text{Al}_2\text{O}_3, 2 \text{SiO}_3$ .—All the above minerals can, according to his experience, be completely decomposed only by caustic potassa or by hydrofluoric acid.

**Talesteinmark.**—According to an analysis performed by Kussin(1) a "talesteinmark," from the iron mine of Zsidovar, not far from Temesvar, in Hungary, has almost the same composition as that from Rochlitz, analysed by Kersten.(2)

SiO <sub>3</sub> .	Al <sub>2</sub> O <sub>3</sub> .	MgO.	Total.
36.01	63.72	traces	99.73

**Anhydrous Silicates with Bases RO. Talc.**—Hermann(3) examined a greenish-white, perfectly transparent talc, in thin laminae (I), from Roschkina, in the district of Slatoust, in the Ural, and Delesse(4) the talc, which occurs in greenish-white translucent laminae, interspersed in euphotide, from Odern (in the Vosges) (II).

	SiO <sub>3</sub> .	Al <sub>2</sub> O <sub>3</sub> .	FeO.	MnO.	NiO.	CaO.	MgO.	CO <sub>2</sub> .	HO.	Total.
I.	59.21	—	2.14	—	0.12	—	34.42	2.50	1.00	99.39
II.	59.61	0.81	3.95	0.56	—	2.88	28.41	—	3.78	100.00

Hermann calculated from his analysis the formula  $8 \text{MgO}, 9 (\text{SiO}_2, \text{CO}_2)$ . According to Rammelsberg, it is  $4 \text{MgO}, 3 \text{SiO}_3 = \text{MgO}, \text{SiO}_3 + 3 \text{MgO}, 2 \text{SiO}_3$ (5).—In the talc of Odern, the ratio of the oxygen in  $\text{RO} : \text{SiO}_3 = 1 : 2.416 = 5 : 12$ . If we look on the water as really a constituent, the formula  $= 4 (\text{RO}, \text{SiO}_3) + \text{RO}, \text{HO}$ . Delesse gives the formula  $3 (\text{RO}), 2 \text{SiO}_3$ .—A peculiar foliated columnar variety of talc, from Kraubat, in Styria, has been described by Haidinger.(6)

**Soapstone.**—Hermann(7) has found that the soapstone of Wunsiedel, in which, as well as in soapstone, examined by him from other localities, Lychnell found no water, gives 5.6 per cent of water when ignited in a wind-furnace. Since former analyses gave also similar quantities of water, while, on the other hand, Lychnell could not have overlooked so large an amount, Hermann admits that there are perfectly anhydrous soapstones, as well as such as give different

(1) Rammelsb. Handw., 4. Suppl., 214.

(2) Schweigg. Journ. LXVI, 16.

(4) Ann. Min. [4] XVI, 333.

(6) Wien. Acad. Ber., 5. Heft, 104.

(3) J. Pr. Chem. XLVI, 232.

(5) Rammels. Handw., 4. Suppl., 219.

(7) J. Pr. Chem. XLVI, 233.

Soap-  
stone.

amounts of water, a fact which perfectly agrees with the pseudomorphous formation of this mineral. (1) The proportions of oxygen of  $\text{MgO} : \text{SiO}_3$  in anhydrous soapstone Hermann assumes to be  $5 : 12 = 3 : 7.2$ , while Rammelsberg (2), after comparing the analyses which are most to be depended on, sets it at  $= 3 : 8$ , and from this establishes the formula as  $9 \text{MgO}, 8 \text{SiO}_3 = 3 \text{MgO}, 2 \text{SiO}_3 + 6 (\text{MgO}, \text{SiO}_3)$ .

(**Pyroxene.**) **Wollastonite.**—Rammelsberg (3) has analysed foliated wollastonite, of silky lustre, and very like tremolite, which Hartig discovered in Hartzburg, in the Hartz (I). It is very similar to the wollastonite from the granular limestone of Auerbach, in the Bergstrasse, of which Winckler (4) has made an analysis (II).

	$\text{SiO}_3$ .	$\text{CaO}$ .	$\text{MgO}$ .	$\text{Fe}_2\text{O}_3; \text{Mn}_2\text{O}_3$ .		Total.
I.	53.01	44.91	1.04	traces	1.59	100.55*
II.	53.00	45.40	traces	0.60	1.00	100.00†

\* Together with traces of  $\text{Al}_2\text{O}_3$ .

† Together with traces of  $\text{CO}_2$ .

**Silicate of Manganese. (Rhodonite.)**—Hermann (5) examined the following varieties of silicate of manganese from North America: (I) Rhodonite, from Sterling, in New Jersey, of sp. gr. 3.63, and with the cleavage of augite; (II) Fowlerite, from the same locality; and (III) Rhodonite, from Cummington, in America, marked as bisilicate of manganese. The sp. gr. of this last was  $= 3.42$ .

	$\text{SiO}_3$ .	$\text{MnO}$ .	$\text{FeO}$ .	$\text{Fe}_2\text{O}_3$ .	$\text{ZnO}$ .	$\text{CaO}$ .	$\text{MgO}$ .	$\text{HO}$ .	$\text{O and CO}_2$ .	Total.
I.	46.48	31.52	7.23	—	5.85	4.50	3.09	1.00	—	99.67
II.	29.48	50.58	—	13.22	—	—	—	3.17	3.55	100.00
III.	48.91	46.74	—	—	—	2.00	2.35	—	—	100.00

The rhodonite from Sterling gives the proportion of oxygen in  $\text{RO} : \text{SiO}_3 = 1 : 1.96 = 1 : 2$ , and thus is manganese-augite. Hermann considers fowlerite as manganese-augite undergoing decomposition. The rhodonite from Cummington gives the foregoing proportion of oxygen  $= 8 : 17.13 = 1 : 2.14$ . Hermann fixes this at  $= 4 : 9$ , and considers this mineral as manganese-amphibole, like Thomson's sesquisilicate of manganese from Sterling, which is cleavable in the direction of a prism of  $123^\circ 30'$ .

**Diopside.**—Kussin (6) has analysed an augite from Brazil which was free from alumina, and of sp. gr. 3.37.

$\text{SiO}_3$ .	$\text{CaO}$ .	$\text{MgO}$ .	$\text{FeO}$ .	Total.
55.61	25.11	17.82	1.20	99.74

This very closely corresponds with the formula  $3 \text{CaO}, 2 \text{SiO}_3 + 3 \text{MgO}, 2 \text{SiO}_3$ , which is that of diopside.

(1) See Annual Report. for 1847 and 1848, II, 502.

(2) Rammelsb. Handw., 4. Suppl., 210.

(3) Pogg. Ann. LXXVII, 265; Rammelsb. Handw., 4. Suppl., 266 (in abstr.)

(4) Jahrb. Pr. Pharm. XVIII, 317.

(5) J. Pr. Chem. XLVII, 5.

(6) Rammelsb. Handw., 4. Suppl., 12.

**Augite.**—Coquand(1) has analysed two minerals till now reckoned as hornblende, consisting of fibrous radiations, of which the one (I), of a gray colour, and of sp. gr. 3.530, occurs frequently as the matrix of lead-, zinc-, copper- and iron-ore, in the environs of the Rocca S. Silvestre, in the Campiglia, in Tuscany; the other (II), of a bottle-green colour, and of sp. gr. 3.462, as well there as in Elba, occurs in large quantity as a gangue-stone.

Augite.

	SiO <sub>3</sub> .	CaO.	FeO.	MnO.	MgO.	Total.
I.	48	21	10	20	traces	99.0
II.	50	15	25	9	—	99.0

The proportion of oxygen of RO : SiO<sub>3</sub> is in I. = 1 : 1.80; in II. = 1 : 1.73; therefore, nearly = 1 : 2, on which account Coquand considers these minerals as augites(2).

F. Sandberger(3) has found augite and hornblende in large quantity and determinably crystallised *beside of one another* in a porphyritic basalt between Schämberg and Härtlingen, in Westerwald. No combinations were found reminding one of uralite.

**Jeffersonite.**—Hermann(4), after a crystallographic and chemical examination of the jeffersonite of Sterling, in New Jersey, has pointed out that it is a variety of augite, which has already for some time been admitted by Breithaupt(5), Dana(6) and others. The form of the crystals examined was  $\infty P. \infty P \infty. (\infty P \infty). 0 P. P.$  The angles of these Hermann found to be as follows:  $\infty P = 87^\circ$ ;  $P : P = 120^\circ 30'$ ;  $0 P : \infty P \infty = 106^\circ$ . The degree of hardness was 5.5 and the sp. gr. = 3.31. The analysis gave :

SiO <sub>3</sub> .	Al <sub>2</sub> O <sub>3</sub> .	FeO.	MnO.	ZnO.	CaO.	MgO.	Loss on ignition.	Total.
49.91	1.93	10.53	7.00	4.39	15.48	8.18	1.20	98.62

numbers which conduct to the known proportions of oxygen in augite, 1 : 2.

**Diallage.**—Delesse(7) examined, in conjunction with Descloizeaux, diallage from the euphotide of Odern, in Upper Alsace, which was transparent in thin laminae, and fusible with great difficulty before the blow-pipe. Besides the known perfect cleavage-planes of mother-of-pearl lustre, there were found in it three others, less perfect, in the direction of  $(\infty P \infty)$  and  $0 P$  of augite, and in the direction of a vertical prism. The latter cut the perfect cleavage-planes situated parallel to  $\infty P \infty$  at angles of  $152^\circ$ , whence it follows that the angle for the cleavage-prism is  $124^\circ$ . (in the clino-

(1) Bull. Géolog. [2] VI, 671.

(2) See Annual Report for 1847 and 1848, II, 400, Augite, No. II.

(3) Pogg. Ann. LXXVI, 111.

(4) J. Pr. Chem. XLVII, 12; Ram'melsb. Handw., 4. Suppl., 111 (in abstr.)

(5) Breithaupt's Handb. III, 585.

(6) Dana's System of Mineralogy, 2. Edit., 365.

(7) Ann. Min. [4] XVI, 331; Compt. Rend. XXX, 149 (in abstr.)



**Diallage.** diagonal principal section), as in hornblende, on which account Delesse considers this diallage as a variety of uralite. Delesse does not mention with certainty whether distinct crystals occur of the form of augite; but this would appear to be the case from his assertion that the chief direction of cleavage is opposite to the angle of  $87^\circ$  in augite. The analysis performed by Delesse indicates likewise its relationship to hornblende.

SiO <sub>2</sub> .	Al <sub>2</sub> O <sub>3</sub> .	Cr <sub>2</sub> O <sub>3</sub> .	FeO.	MnO.	CaO.	MgO.	Loss on ignition.	Total.
49.30	5.50	0.30	0.43	0.51	15.43	17.61	0.85	98.93

(**Amphibole.**) **Hornblende.**—Delesse examined also two varieties of hornblende out of diorite, in the Vosges. The one (I), in very fibrous laminæ from the diorite of Pont St. Jean, near St. Maurice(1), of a beautiful green, transparent in thin laminæ, cleaving at an angle of  $124^\circ$ , and with sp. gr. 3.059. The other (II), out of the diorite of Faymont(2), is black and foliated, but is also found in distinct crystals. A hornblende from Zsidovác, in Hungary (III), of sp. gr. 3.136, has been analysed by Kussin(3), another from Haavi, in Fillefjeld (IV), by Suckow(4).

	SiO <sub>2</sub> .	Al <sub>2</sub> O <sub>3</sub> .	Cr <sub>2</sub> O <sub>3</sub> .	FeO.	MnO.	CaO.	MgO.	KO.	NaO.	Loss on ignition.	Total.
I.	50.04	8.95	0.24	9.59	0.20	11.48	18.02*	0.08	0.81	0.59	100.00
II.	41.99	11.86	—	22.22	—	9.55	12.59*	1.32		0.47	100.00
III.	46.01	10.49	—	10.03	3.46	13.80	15.09	—	—	—	98.88
IV.	45.37	14.81	—	8.74	1.50	14.91	14.33	—	—	—	99.66

\* In I and II the magnesia was not directly determined.

**Byssolite.**—Kennigott(5) has examined, crystallographically, byssolite, and in the fine hair-like needles from the Tyrol, has clearly distinguished the planes  $\infty P$ ,  $\infty P \infty$  and  $(\infty P \infty)$ . He was even able to effect a measurement, which gave  $\infty P = 124^\circ 21'$ , as in hornblende. The needles of byssolite, from St. Gotthard, he recognised as the combinations  $\infty P$ .  $(\infty P \infty)$ .

**Boltonite.**—According to B. Silliman, jun.(6), the mineral named by Shepard, from its locality, Bolton, in Massachusetts(7), is different from the silicate of magnesia of Thomson(7), with which it was once considered as identical. The genuine boltonite is granular, with glassy lustré, lead-gray, and becomes yellow by degrees in the

(1) Ann. Min. [4] XVI, 339.

(2) Ann. Min. [4] XVI, 359.

(3) Rammelsb. Handw., 4. Suppl., 102.

(4) Suckow, die Verwitterung im Mineralreich, 1. Heft. 143; Rammelsb. Handw., 4. Suppl., 102 (in abstr.)

(5) Kennigott's Min. Untersuchungen, 1. Heft. 5 und 77.

(6) Sill. Am. J. [2] VIII, 391; Phil. Mag. [3] XXXV, 462 (in abstr.); J. Pr. Chem. XLIX, 205.

(7) See Shepard's Treatise on Mineralogy, 78, and Dana's System of Mineralogy, 2nd Edit., 345, and Dufrénoy's Minéralogie, III, 545.

air, which according to Saemann, from whom Silliman received the sample for his analysis, arises from the oxidation of magnetic iron mixed with it(?). Its degree of hardness is = 5.5. Its sp. gr. = 3.008. The yellow variety gave:

Boltonite.

SiO <sub>3</sub> .	Al <sub>2</sub> O <sub>3</sub> .	MgO.	FeO.	CaO.	Total.
46.062	5.667	38.149	8.632	1.516	100.026

Silliman deduces from this the formula 2 RO, (SiO<sub>3</sub>, Al<sub>2</sub>O<sub>3</sub>).

Thomson's analysis had given 56.64 SiO<sub>3</sub>, 36.52 MgO, 2.46 Fe<sub>2</sub>O<sub>3</sub>, and 6.07 Al<sub>2</sub>O<sub>3</sub>.

**Chrysolite.**—Beck (I) and Hermann (II) analysed a transparent, olive-green, chrysolite, of sp. gr. 3.39 to 3.43, which occurred embedded in talc-slate in compact fragments, at Syssek, in the Ural(1).

	SiO <sub>3</sub> .	MgO.	FeO.	NiO.	Total.
I.	39.208	44.064	17.445	—	100.717
II.	40.04	42.60	17.58	0.15	100.37

**Olivine.**—Baumann(2) examined, under Rammelsberg's direction, an already somewhat weathered, brownish olivine, from the basalt of Bollenreuth, in the Fichtelgebirge (I), and Rammelsberg(3) himself analysed the olivine from the basalt of Engelhaus, near Karlsbad (II).

	SiO <sub>3</sub> .	MgO.	FeO.	Total.
I.	44.69	40.92	14.22	99.83
II.	39.34	45.81	14.85	100.00

**Troostite. Willemite.**—Hermann(4) found, by comparing the properties of troostite with those of willemite, from Sparta, in North America, that they agree in essential particulars. The chemical examination of a specimen of troostite of 4.02 sp. gr., proved the latter to be a variety of willemite containing much manganese.

SiO <sub>3</sub> .	ZnO.	MnO.	MgO.	FeO.	Loss on ignition.	Total.
26.80	60.07	9.22	2.91	trace	1.00	100.00

From this the mineral has the formula 3 (ZnO, MnO, MgO), SiO<sub>3</sub>.

**Anhydrous Silicates with Bases R<sub>2</sub>O<sub>3</sub> and RO. Epidote. (Pistazite; Thulite.)**—Bacr(5) has analysed the pistazite from Bourg d'Oisans (I a and b), and Berlin(6), the thulite of the Iron Mine of

(1) J. Pr. Chem. XLVI, 222; Rammelsb. Handw., 4. Suppl., 172 (in abstr.)

(2) Rammelsb. Handw., 4. Suppl., 14.

(3) Ibid., 16.

(4) J. Pr. Chem. XLVII, 9; Rammelsb. Handw., 4. Suppl., 114 (in abstr.)

(5) Polyt. Centralblatt, 1849, No. 25; Arch. Pharm. [2] LVII, 274; J. Pr. Chem. XLVII, 461 (in abstr.)

(6) Pogg. Ann. LXXVIII, 414.

Anhydrous  
silicates  
with  
bases  
 $R_2O_3$   
and  
RO.  
Epidote.  
(Pistazite;  
thulite.)

Klodeberg, near Arendal (II). The last was massive, and possessed a sp. gr. of 3.34.

	$SiO_2$	$Fe_2O_3$	$Al_2O_3$	MnO.	CaO.	MgO.	NaO.	$VO_2$	HO.	Total.
I a.	37.78	16.03	21.75	—	23.86	0.47	—	—	—	99.89
I b.	—	15.91	20.74	—	23.06	0.74	0.41	—	—	—
II.	40.28	1.54	31.84	0.95	21.42	0.66	—	0.22	1.32	98.24

In I a. it was treated with carbonate of soda, and in I b. with hydrofluoric acid. In II. the alkalies were not determined.—The analyses of both the epidotes lead to the proportions of oxygen of  $RO : R_2O_3 : SiO_2 = 1 : 2 : 3$ .

Rammelsberg(1) has communicated the details of his new analysis of the green epidote from Arendal, which was mentioned in the last Annual Report, II, p. 404; whereby he points out, that his early analysis(2) is correct, and that this epidote neither contains protoxide of iron, which Hermann(3) found in his analysis, nor does it give proportions of oxygen different from those before quoted, and generally adopted for epidote. Two experiments with the unignited mineral, in which it was decomposed by fusion with borax, and the solution in hydrochloric acid digested with metallic copper, gave 15.207 and 15.98 per cent of sesquioxide of iron; two other experiments, in which the mineral upon ignition was decomposed by hydrochloric acid, gave 16.11 and 16.44 per cent of sesquioxide of iron. After separating, by carbonate of baryta, the sesquioxide of iron from the solution of the ignited mineral in hydrochloric acid, no protoxide of iron could be detected by means of terchloride of gold. The complete analysis gave:

$SiO_2$	$Al_2O_3$	$Fe_2O_3$	CaO.	MgO.	Loss on ignition.	Total.
38.76	20.36	16.35	23.71	0.44	2.00	101.62

from which it follows that the ratio of oxygen in the above are  $= 1 : 2.08 : 2.92$ , or  $= 1 : 2 : 3$ . Rammelsberg has, moreover, pointed out that all Hermann's analyses, as well of epidote as of bucklandite, conduct to this and no other ratio of the oxygen, if one takes into calculation the unavoidable errors of analyses, as well as the circumstance that the method used by Hermann for determining the state of oxidation of the iron could lead to no exact results.

**Orthite.**—Rammelsberg has communicated(4) the result of an analysis of orthite from Miask (of sp. gr. = 3.647), which he had performed some considerable time before, and he has calculated, from the data of Hermann's last analysis(5), the amount of ses-

(1) Pogg. Ann. LXXVI, 95.

(2) Rammelsb. Handw., 2. Suppl., 48.

(3) See Annual Report for 1847 and 1848, Table to Vol. II, 403, Nos. 4 and 7.

(4) Pogg. Ann. LXXVI, 96; Rammelsb. Handw., 4. Suppl., 174 (in abstr.)

(5) See Annual Report for 1847 and 1848, II, 404, Analysis No. II.

quioxide of iron which had been then found to be 16·13 per cent (I) as protoxide.—He has also directly determined the amount of iron in both degrees of oxidation contained in a specimen of orthite of Hitteroën, obtained from Scheerer, of sp. gr. 3·546, and thereby he has corrected (II) Scheerer's last analysis of this orthite(1). In two experiments he obtained 7·93 and 8·07 per cent of sesquioxide.

Orthite.

	$SiO_3$	$Al_2O_3$	$Fe_2O_3$	$FeO$	$CuO$	$CeO$ & $LaO$	$YO$	$CaO$	$MgO$	$KO$	$HO$	Total
I.	34·08	16·86	7·35	7·90	0·13	21·38	—	9·28	0·95	—	1·32	99·25
II.	33·81	13·04	8·16	8·30	—	20·50	1·45	9·42	0·38	0·67	3·38	99·11

Hence both orthites agree well together, except in the amount of water they contain, and conduct to the formula established by Hermann(2) for the orthite of Miask,  $3 RO, SiO_3 + R_2O_3, SiO_3$  (without the water).

Rammelsberg imagines that the orthites also of Werchoturje, of Stockholm, and of Fillefeld, have the same composition, and considers them all as originally anhydrous.

**Idocrase. (Vesuvian.)**—Rammelsberg(3) has also communicated the results of three analyses made some time ago, of vesuvian, from Kongsberg. For the analysis, No. I. a well crystallised; for Nos. II. and III. an amorphous, apparently somewhat decomposed mineral, of 3·384 sp. gr., was taken.

	$SiO_3$	$Al_2O_3$	$Fe_2O_3$	$CaO$	$MgO$	Loss on ignition.	Total
I.	37·24	16·80	7·21	33·60	5·26	0·22	100·33
II.	38·26	15·13	8·38	34·14	3·68	0·41	100·00
III.	38·39	13·84	9·98	33·76	3·81	0·41	100·19

By a separate experiment there were found in the amorphous mineral 9·48 per cent of sesquioxide, and 0·45 per cent of protoxide of iron.—The analyses lead to the formula of garnet. See Annual Report for 1847 and 1848, II, p. 406.

**Garnet. (Almandine; Melanite.)**—A. Besnard(4) has analysed a remarkably beautiful columbine-red almandine, of sp. gr. 4·2, from Albernreit, near Waldsassen, in Bavaria (I); and W. Fischer(5), a crystallised iron garnet (melanite), from Franconia, in North America (II).

	$SiO_3$	$Al_2O_3$	$Fe_2O_3$	$FeO$	$MnO$	$CaO$	$MgO$	Total
I.	38·76	21·00	—	32·05	6·43	—	3·95	102·19
II.	38·85	—	28·15	—	—	32·00	—	99·00

(1) Pogg. Ann. LXI, 636.

(2) See Annual Report for 1847 and 1848, II, 404, where a preliminary notice of Rammelsberg's experiments was given.

(3) Rammelsb. Handw., 4. Suppl., 254.

(4) Correspondenzbl. d. Zoolog. Vereins in Regensburg, 1849, III, 30; Jahrb. Miner. 1849, 5. Heft, 563 (in abstr.)

(5) Sill. Am. J. [2] IX, 84.

**Scapolite.** **Scapolite.**—Suckow(1) has analysed a blueish-gray scapolite, of sp. gr. 2·64, from Malsjö.

SiO <sub>2</sub> .	Al <sub>2</sub> O <sub>3</sub> .	FeO.	CaO.	Volatile matter.	Total.
48·17	28·27	2·14	19·04	2·00	99·62

**Nuttallite.**—L. Stadtmüller(2) has analysed, under the direction of B. Silliman, jun., the nuttallite from Bolton, in Massachusetts, and found that it is identical with scapolite, which Hausmann(3) and Dana(4) have already mentioned. The analysis gave:

SiO <sub>2</sub> .	Al <sub>2</sub> O <sub>3</sub> .	Fe <sub>2</sub> O <sub>3</sub> .	CaO.	KO.	NaO and MnO.	HO.	Total.
45·791	30·107	1·861	17·406	3·486	traces	1·630	100·281

The ratio of oxygen in RO : R<sub>2</sub>O<sub>3</sub> : SiO<sub>3</sub> is = 1 : 2·99 : 4·363 = 3 : 9 : 12, as in wernerite.

**Felspar. Orthoclase.**—Delesse(5) has analysed grayish-white crystallised orthoclase (I), from a large erratic protogynic block that had come down from the Mer de Glace, at Chamonny, and (6) flesh-coloured crystallised orthoclase (II) out of the pegmatite, from the Etang du Xénois, near Remiremont, in the Vosges. Furthermore, Moll has analysed(7) under Rammelsberg's direction, a bluish-white orthoclase, from Mulde, near Freiberg (III), and Rammelsberg himself(8) a somewhat weathered orthoclase (IV) from Auersberg, in the Hartz. The sp. gr. of none of them was made out.

	SiO <sub>2</sub> .	Al <sub>2</sub> O <sub>3</sub> .	Fe <sub>2</sub> O <sub>3</sub> .	MnO.	CaO.	MgO.	KO.	NaO.	HO.	Total.
I.	68·48	19·06	trace	—	0·63	trace	10·52	2·30	—	98·99
II.	63·92	20·05	—	0·30	0·75	0·60	10·41	3·10	0·41	99·54
III.	65·75	17·72	—	—	0·82	—	12·05	3·66	—	100·00
IV.	66·26	16·98	0·31	—	0·43	0·11	14·42	0·20	1·29	100·00

**Albite.**—G. Brush and C. Weld(9) have analysed, at the instigation of B. Silliman, jun., a grayish-white granular albite, somewhat like dolomite, which had been previously taken for indianite. Its sp. gr. was 2·619, it did not tinge the flame yellow, and it possessed the unusually high degree of hardness of 7 to 7·25,

(1) Suckow, Verwitterung im Mineralreich, 1. Heft, 138; Rammelsb. Handw., 4. Suppl., 203 (in abstr.)

(2) Sill. Am. J. [2] VIII, 394; Phil. Mag. [3] XXXV, 464 (in abstr.); J. Pr. Chem. XLIX, 207.

(3) Hausmann's Lehrbuch, I, 621.

(4) Dana's System of Mineralogy, 2nd Edit., 358.

(5) Bull. Géol. [2] VI, 232; Ann. Ch. Phys. [3] XXV, 114 (in abstr.); Rammelsb. Handw., 4. Suppl., 188; Phil. Mag. [3] XXXIV, 234.

(6) Ann. Min. [4] XVI, 99; Compt. Rend. XXIX, 24 (in abstr.); Arch. Ph. Nat. XI, 318; J. Pr. Chem. XLVII, 460.

(7) Rammelsb. Handw., 4. Suppl., 69.

(8) Ibid., 70.

(9) Sill. Am. J. [2] VIII, 389; Phil. Mag. [3] XXXV, 484 (in abstr.)

which it owes, according to Silliman, like indianite, to its occurrence with corundum. The specimen analysed by Brush (I), came from Lancaster County, in Pennsylvania; that analysed by Weld (II), from Unionville, in Chester County, Pennsylvania.—The same mineral from two other localities, Wetchester (III) and Wilmington (IV), in Pennsylvania, had been jointly investigated in 1842, by Boye and Booth(1).

Albite.

	SiO <sub>2</sub> .	Al <sub>2</sub> O <sub>3</sub> .	Fe <sub>2</sub> O <sub>3</sub> .	CaO.	MgO.	KO.	NaO.	HO.	Total.
I.	66.65	20.78	—	2.05	0.52	—	9.36	—	99.36
II.	66.85	21.88	—	1.78	0.48	—	8.78	0.48	100.25
III.	67.72	20.54	trace	0.78	0.34	0.16	10.65	—	109.19
IV.	65.46	20.74	0.54	0.71	0.74	1.80	9.98	—	99.97

**Oligoclase.**—Delesse(2) found, near the orthoclase, in the protogyne from the Mer de Glace, oligoclase also. This is mostly white, or greenish and dull, and possesses the well-known twin striæ, and a sp. gr. of 2.633. Pure crystals were selected, and taken for the analysis (I).—Delesse(3) also arranged as oligoclase, on account of its amount of lime, and its somewhat high sp. gr. of 2.686, the felspar-like constituent of the porphyry of Schirmeck, in the Vosges (II), although this gave on analysis the oxygen-ratio of albite. The alkalies and magnesia were not directly determined by Delesse.

	SiO <sub>2</sub> .	Al <sub>2</sub> O <sub>3</sub> .	CaO.	MgO.	NaO.	KO.	HIO.	Total.
I.	63.25	23.92	3.23	0.32	6.88	2.31	—	99.91
II.	65.74	18.49	4.17		10.60		1.00	100.00

**Andesine.**—Delesse(4) has found andesine also in the diorite from Faymont, in the Vosges(5). The mineral appeared in it in yellowish-white stellated groups of laminæ, often also in tolerably thick crystals. The amount of alkali it contained was not directly determined in the analysis.

SiO <sub>2</sub> .	Al <sub>2</sub> O <sub>3</sub> .	CaO.	NaO and KO.	HO.	Total.
59.38	25.57	6.50	7.30	1.25	100.00

Together with traces of sesquioxide of iron.

**Labradorite.**—Delesse has investigated the composition of labradorite, or of some mineral akin to it, from the following rocks: (I) from the euphotite of Mont Genève, in the Alps(6), (Saussure's

(1) Proceedings of the American Phil. Soc. II, 190; Phil. Mag. [3] XXXVI, 319.

(2) Bull. Géol. [2] VI, 234; Ann. Ch. Phys. [3] XXV, 114 (in abstr.); Phil. Mag.

[3] XXXIV, 234; Rammelsb. Handw., 4. Suppl., 188.

(3) Ann. Min. [4] XVI, 363.

(4) Ibid., 357.

(5) See Annual Report for 1847 and 1848, II, 410.

(6) Bull. Géol. [2] VI, 547; Ann. Min. [4] XVI, 239; Arch. Ph. Nat. XII, 325 (in abstr.)

Labradorite.

jade, Beudant's saussurite), a tough, lamellar, indistinctly cleavable mineral, of a resinous lustre and greenish-white colour, in twin forms, of sp. gr. between 2·8 and 3·0, and decomposable with effervescence by acids when in fine powder; (II) from the amygdaloid porphyry in the neighbourhood of Oberstein on the Nahe(1), in colourless, transparent crystals, with vitreous lustre, and sp. gr. 2·642; (III) from the diorite of Pont Jean, near St. Maurice, at the foot of the Ballon d'Alsace(2); (IV) from the euphotide of Odern, in Upper Alsace(3).—The two last are greenish-white, with resinous lustre, and presenting fine twin striations. Nos. I and IV, presented under the microscope, after heating, fine talc-like leaves and particles of a mineral like serpentine. All of these effervesced in some degree with acids.—To labradorite might also belong a specimen analysed by Deville(4), consisting of a much decomposed felspar (V), from Rothenbrunn, near Schemnitz, which, according to Deville, has been originally andesine, of which the lime and silicic acid has been partially replaced by water and carbonic acid.

	SiO <sub>3</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	FeO	CaO	MgO	KO	NaO	CO <sub>2</sub>	H <sub>2</sub> O	Total
I.	49·73	29·65	—	0·85	11·18	0·56	0·24	4·04	3·75		100·00
II.	53·89	27·66	0·97	—	8·28	—	1·28	4·92	3·00		100·00
III.	53·05	28·66	—	0·90	6·37	1·51	2·80	4·12	2·40		99·81
IV.	55·23	24·24	1·11	—	6·86	1·48	3·03	4·83	3·05		99·83
V.	53·92	26·69	—	1·08	6·98	1·68	1·20	4·02	2·93	1·40	99·90

If we put the oxygen of the alumina throughout as =3, the oxygen of the silicic acid will be in I. = 5·70, in II. = 6·68, in III. = 6·30, in IV. = 7·54, in V. = 6·87; on the average in each, therefore nearly = 3·6, which is what the formula of labradorite requires.

**Glaucolite.**—Giwartowsky(5) has analysed the glaucolite of the Baikal Mountains. The mineral was surrounded and interspersed with yellowish-green mica, and its sp. gr. was 2·65. Giwartowsky's description of the mineral furnished nothing new.

SiO <sub>3</sub>	Al <sub>2</sub> O <sub>3</sub>	CaO	MgO	MnO	FeO	NaO	KO	H <sub>2</sub> O	Total
50·49	28·12	11·31	2·67	0·59	0·39	3·10	1·00	1·78	99·45

This is almost exactly the same composition which Bergemann found for it(6).

(1) Ann. Min. [4] XVI, 512.

(2) Ann. Min. [4] XVI, 342; Compt. Rend. XXX, 176 (in abstr.)

(3) Ann. Min. [4] XVI, 324; Compt. Rend. XXX, 148 (in abstr.)

(4) Bull. Géol. [2] VI, 410.

(5) Bull. de la Soc. Imp. d. Nat. de Moscou, XXI, 548; J. Pr. Chem. XLVII, 380 (in abstr.)

(6) Pogg. Ann. IX, 267.

**Lepolite.**—Hermann(1) has examined lepolite(2), from Lojo (I), and from Orijärvi, in Finland (II), and found that it has the same composition as anorthite, but is distinguished from it in this, that it belongs to the feldspars with left-handed inclination.—The measurement of pretty large, transparent, almost colourless crystals, with a vitreous lustre, gave  $\infty'P : \infty P' = 120^\circ 30'$ , in the brachydiagonal principal section, and the inclination of  $OP$  upon the principal axis  $= 64^\circ 30'$ . The cleavage was found to be in the direction  $OP$  and  $\infty P \infty$ . The degree of hardness is  $= 6$ , and the sp. gr.  $= 2.75$  to  $2.77$ . The mineral is fusible only on the edges to a transparent glass; by strong acids it is decomposed when in a fine powder. The analysis gave:

	$SiO_3$ .	$Al_2O_3$ .	$Fe_2O_3$ .	$CaO$ .	$MgO$ .	$NaO$ .	Loss on ignition.	Total.
I.	42.80	35.12	1.50	14.94	2.27	1.50	1.56	99.69
II.	42.50	33.11	4.00	10.87	5.87	1.69	1.50	99.54

According to Hermann, amphotelite, bytownite, latrobit, and indianite, belong either to lepolite or to anorthite, as they assimilate in composition and form to the latter, but it is still to be determined whether they are inclined to the right or to the left(3).

**Lindsayite.**—Hermann(4) has investigated the lindsayite (linseite), from the Lindsay Mine, at Orijärvi, in Finland, which was formerly analysed by Komonen. According to Hermann's drawing of it, its crystalline form is like that of anorthite. Large crystals are always rough, curved, much split, and interspersed with copper pyrites, and iron and magnetic pyrites. In small crystals, which are often brilliant, Hermann determined  $\infty P = 120^\circ$ , and the inclinations of  $OP$ ,  $-P \infty$ ,  $2P \infty$  and  $-2P \infty$  upon the principal axis  $= 65^\circ$ ,  $64^\circ 30'$ ,  $23^\circ$  and  $35^\circ$ . The inclination of  $OP : (\infty P \infty)$  could not be determined, on account of the curved character of these planes, and it exhibited cleavage only in the direction  $OP$ , and indeed only after heating.—Its fracture is splintery, the hardness  $= 4$ , and the sp. gr.  $= 2.83$ . The colour is black outside, and dirty peach-blossom-red, or blueish-gray inside. Before the blow-pipe the mineral melts with difficulty on the edges. By acids it is not at all decomposed. The analysis gave:

$SiO_3$ .	$Al_2O_3$ .	$Fe_2O_3$ .	$FeO$ .	$MgO$ .	$KO$ .	$NaO$ .	$HO$ .	Total.
42.22	27.55	6.98	2.00	8.85	3.00	2.53	7.00	100.13

together with traces of fluorine and phosphoric acid. Hermann

(1) J. Pr. Chem. XLVI, 387; Arch. Ph. Nat. XI, 315 (in abstr.); Rammelsb. Handw., 4. Suppl., 140.

(2) See Breithaupt's Handb. d. Min. III, 530.

(3) J. Pr. Chem. XLVI, 390.

(4) J. Pr. Chem. XLVI, 393; XLVIII, 254; Arch. Ph. Nat. XI, 315 (in abstr.)



Lind-  
sayite.

looks on the amount of water present as originally so, and makes the oxygen ratio of  $\text{RO} : \text{R}_2\text{O}_3 : \text{SiO}_3 : \text{HO} = 1 : 3 : 4 : 1$ , and the formula of it  $\text{RO}, \text{SiO}_2 + \text{R}_2\text{O}_3, \text{SiO}_2 + \text{HO} = 3 \text{RO}, \text{SiO}_3 + 3 (\text{R}_2\text{O}_3, \text{SiO}_3) + 3 \text{HO}$ , from which lindsayite would be lepolite or anorthite with water of crystallisation. Breithaupt(1) and Rammelsberg(2) very justly consider, however, that the mineral is a pseudomorph; both on account of its containing water, and on account of its character, especially in the large crystals.

**Indianite. Anorthite.**—Brush(3) analysed, under the direction of B. Silliman, jun., genuine Indian indianite. It was granular, pale-red, here and there gray or blackish, possessed a hardness of 7 to 7.25, and a sp. gr. of 2.668 (see p. 527). Before the blow-pipe it was infusible. Digested in cold hydrochloric acid it became gelatinised. Analysis gave:

$\text{SiO}_3$ .	$\text{Al}_2\text{O}_3$ .	$\text{CaO}$ .	$\text{NaO}$ .	Total.
42.09	38.89	15.78	4.08	100.84

together with traces of sesquioxide of iron. The oxygen-ratio of  $\text{RO} : \text{R}_2\text{O}_3 : \text{SiO}_3$  is  $= 1 : 3.2 : 4.0$ , which is exactly that of anorthite, to which also it belongs, according to the angle-measurement given by Brooke of  $95^\circ 15'$  and  $84^\circ 45'$ .

**Hyposclerite.**—Hermann(4) has investigated hyposclerite(5). The measurement of it gave  $\text{OP} : \infty \text{P} = 87^\circ$ ;  $\text{OP} : \infty' \text{P} = 114^\circ 30'$ ;  $\infty \text{P} : \infty' \text{P} = 119^\circ$  in the brachydiagonal principal section. The sp. gr. is  $= 2.66$ , and the hardness  $= 5.5$ . Before the blow-pipe the mineral is fusible to an enamel, but only on its edges. The analysis of it gave:

$\text{SiO}_3$ .	$\text{Al}_2\text{O}_3$ .	$\text{Fe}_2\text{O}_3$ .	$\text{Mn}_2\text{O}_3$ .	$\text{CeO}, \text{LaO}$ .	$\text{CaO}$ .	$\text{MgO}$ .	$\text{KO}$ .	$\text{NaO}$ .	$\text{H}_2\text{O}$ .	Total.
56.43	21.70	0.75	0.39	2.00	4.83	3.39	2.65	5.79	1.87	99.80

The analysis conducts to the oxygen-ratio of  $\text{RO} : \text{R}_2\text{O}_3 : \text{SiO}_3 = 1 : 2 : 3$ , which has not as yet been found in the felspar-series, and which is considered by Hermann himself as not yet established. From this, hyposclerite would have the formula  $3 \text{RO}, 2 \text{SiO}_3 + 2 (\text{R}_2\text{O}_3, 2 \text{SiO}_3)$ .

**Mica. Potassa-Mica.**—Kussin(6) has analysed biaxial mica of 2.817 sp. gr. from Zsidovacz in Hungary (1); Rammelsberg(7) a

(1) J. Pr. Chem. XLVII, 236.

(2) Rammelsb. Handw., 4. Suppl., 143.

(3) Sill. Am. J. [2] VIII, 391; Phil. Mag. [3] XXXV, 486 (in abstr.)

(4) J. Pr. Chem. XLVI, 396; Arch. Ph. Nat. XI, 315 (in abstr.); Rammelsb. Handw., 4. Suppl., 110.

(5) See Breithaupt's Handb. d. Min. III, 512.

(6) Rammelsb. Handw., 4. Suppl., 75.

(7) Ibid., 75.

silver-white mica of 2.831 sp. gr., and of locality unknown (II).—Delesse has investigated two varieties; the one (III) from the pegmatite of Ceux, near St. Etienne, in the Vosges(1), the other (IV) from a protogyne block at Chamouny(2). The mica of Ceux is of silvery lustre, grayish-white; by transmitted light its colour is lilac, and its sp. gr. is from 2.804 to 2.817. Before the blow-pipe it melts with greater difficulty than lepidolite, and is not attacked by acids after ignition. The mica from Chamouny is like chlorite, and forms dark-green hexagonal prisms, with a difficult cleavage in the direction of the base, and with their edges obliquely inclined to the base. Before the blow-pipe it is fusible with great difficulty. By hydrochloric acid it is decomposed. Its sp. gr. = 3.127.

	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	FeO	MnO	CaO	MgO	KO	NaO	H <sub>2</sub> O	Fl.	Total.
I.	48.07	38.41	trace	—	trace	—	—	10.10	—	3.42	—	100.00
II.	47.84	32.36	3.06	—	—	0.29	1.28	10.25	1.55	2.43	—	99.06
III.	46.23	33.03	3.48	—	trace	trace	2.10	8.87	1.45	1.12*	—	99.28
IV.	41.22	13.92	21.31	5.03	1.09	2.58	4.70	6.05	1.40	0.90	1.58	99.78

\* Together with some HF.

The oxygen-ratios of these micas are as follows:

	RO.	:	R <sub>2</sub> O <sub>3</sub>	:	SiO <sub>2</sub>	:	HO.
I.	1	:	10.48	:	14.88	:	1.77
II.	1	:	5.9	:	9.2	:	0.88
III.	1	:	7.18	:	10.69	:	1.59
IV.	1	:	2.38	:	4.08	:	0.15

Rammelsberg calculated for (I) the formula 2 [KO, SiO<sub>2</sub>, + 3 (Al<sub>2</sub>O<sub>3</sub>, SiO<sub>2</sub>)] + 3 HO, and for (II) the formula KO, SiO<sub>2</sub> + 2 (Al<sub>2</sub>O<sub>3</sub>, SiO<sub>2</sub>) + HO.—For the mica of Ceux (III) the formula 2 (RO, SiO<sub>2</sub>) + 5 (R<sub>2</sub>O<sub>3</sub>, SiO<sub>2</sub>) + 3 HO comes very closely correct.—The analysis of the chlorite-like mica from Chamouny agrees very nearly with the formula 2 (2 RO, SiO<sub>2</sub>) + 3 (R<sub>2</sub>O<sub>3</sub>, SiO<sub>2</sub>), from which this would appear to belong to the uniaxial mica. If we take into account the amount of fluorine present, the formula 7 (RO, SiO<sub>2</sub>) + 3 (2 R<sub>2</sub>O<sub>3</sub>, SiO<sub>2</sub>) + RFl would very nearly represent its composition. Delesse calls this mica, from its large amount of iron, ferruginous mica.

**Emerylite.**—B. Silliman, jun., has obtained from L. Smith a mineral distinguished by the name of emerylite, which is like mica, and occurs with emery in Asia Minor and Naxos. By a preliminary examination, Smith(3) found for it the following composition:

SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Zr <sub>2</sub> O <sub>3</sub>	CaO	Fe <sub>2</sub> O <sub>3</sub> , Mn <sub>2</sub> O <sub>3</sub> , KO.	Total.
30	50	4	13	3	100

(1) Ann. Min. [4] XVI, 100; Compt. Rend. XXIX, 24 (in abstr.); Arch. Ph. Nat. XI, 318; J. Pr. Chem. XLVII, 460.

(2) Bull. Géol. [2] VI, 236; Ann. Ch. Phys. [3] XXV, 117 (in abstr.); Phil. Mag. [3] XXXV, 234; Rammelsb. Handw., 4. Suppl., 189.

(3) Sill. Am. J. [2] VII, 285.

**Emeryllite.** from which Silliman calculated the formula  $3 \text{RO}, \text{SiO}_3 + 3 (2 \text{R}_2\text{O}_3, \text{SiO}_3)$ .—In the examination of the small specimen of this mineral obtained from Smith, Silliman could find no zirconia, whilst it contained water and traces of hydrofluoric acid.

In consequence of the occurrence of emeryllite Silliman(1) has investigated the accompaniments of the American emery more exactly, and found in them not only emeryllite, but moreover three other new sorts of mica, which he called corundellite, euphyllite and clingmanite.

The American emeryllite is found in considerable masses at Village Green near Aston, Chester County, in Pennsylvania. It is apparently hexagonal, and as readily split as ordinary mica, for which it has been hitherto taken. The white, transparent, and silvery laminae of mother-of-pearl-lustre are not elastic and very brittle. Their hardness is = 3.5, and their sp. gr. = 2.995. Before the blow-pipe the mineral glows strongly, and only melts with difficulty at the edges where they are thin. The following analyses, in which the alkalis were not directly determined, were performed by J. Crawe under Silliman's direction.

	$\text{SiO}_3$ .	$\text{Al}_2\text{O}_3$ .	$\text{CaO}$ .	$\text{MgO}$ .	$\text{KO}, \text{NaO}$ .	$\text{HO}$ .	Total.
I:	32.311	49.243	10.663	6.298	2.215	5.270	100.00
II.	31.060	51.199	9.239	0.283	2.969	5.270	100.02
III.	31.261	51.603	10.146	0.499	1.221	5.270	100.00
Mean	31.544	50.682	10.016	0.360	2.135	5.270	100.00

The oxygen-ratio of  $\text{RO} : \text{R}_2\text{O}_3 : \text{SiO}_3 : \text{HO}$  is on the average = 2.63 : 18 : 12.45 : 3.56. Silliman puts this at = 3 : 18 : 12 : 3, and gives the formula as  $3 \text{RO}, \text{SiO}_3 + 3 (2 \text{R}_2\text{O}_3, \text{SiO}_3) + 3 \text{HO}$ .

**Corundellite.**—Corundellite, externally very like emeryllite, occurs with corundum and emery at Unionville, Chester County, in Pennsylvania, in what seems to be hexagonal, whitish-yellow, broadly laminated and brittle masses, which often are interspersed with corundum. Its hardness is = 3.5, its sp. gr. = 3. In other respects it behaves just as emeryllite.—The analysis of it was made by Crooke.

$\text{SiO}_3$ .	$\text{Al}_2\text{O}_3$ .	$\text{CaO}$ .	$\text{KO}$ .	$\text{NaO}$ .	$\text{HO}$ and little $\text{Fl}$ .	Total.
35.708	53.131	7.271	1.224	0.413	2.303	100.050

The oxygen-ratio of  $\text{RO} : \text{R}_2\text{O}_3 : \text{SiO}_3 : \text{HO}$  is here = 1.05 : 12 : 8.31 : 0.89. Silliman puts these at = 1 : 12 : 9 : 1, and from this establishes the formula as  $\text{RO}, \text{SiO}_3 + 2 (2 \text{R}_2\text{O}_3, \text{SiO}_3) + \text{HO}$ . He suspects that corundellite is very probably identical with margarite.

**Euphyllite.**—Euphyllite is also found at Unionville associated with black tourmaline. It is externally grayish or sea-green, and has

(1) Sill. Am. J. [2] VIII, 377; Phil. Mag. [3] XXXV, 450 (in abstr.); J. Pr. Chem. XLIX, from 195 to 201.

slightly the lustre of mother-of-pearl; but on very perfect cleavage-planes it is white, and of very strong pearly lustre; perhaps more so than heulandite. The very brittle laminae are perfectly transparent. The hardness is =3, and the sp. gr. =2.963. Before the blow-pipe the mineral exfoliates, glows more strongly than emerylite and corundellite, and melts at the edges. The analysis performed by Crooke gave:

Euphyllite.

$SiO_3$ .	$Al_2O_3$ .	CaO.	MgO.	NaO.	HO.	Total.
39.042	51.378	3.193	1.088	0.871	4.593	100.165

The ratio of oxygen in  $RO : R_2O_3 : SiO_3 : HO$  is  $=1.17 : 18 : 15.52 : 3.06 = 1 : 18 : 15 : 3$ , and leads to the formula  $RO, SiO_3 + 2 (3 R_2O_3, 2 SiO_3) + 3 HO$ .

**Clingmanite.**—The clingmanite found by Clingman occurs with corundum in North Carolina. Silliman left it undecided whether or not this has to be looked on as new, because the genuine specimen in his possession was not sufficient for an exact investigation. The hardness was =3, and the sp. gr. was found to be =2.94 to 3.008. With regard to the remaining properties, he determined them to be nearly in conformity with those of the foregoing minerals. An analysis gave 36.369 per cent of  $SiO_3$ , 42.373  $Al_2O_3$ , 10.141 CaO, 4.462 MgO, 1.418 HO, and about 5 per cent NaO.

Zirconia, which Smith announced as present, as well as lithia and boracic acid, were found in none of these minerals, but fluorine, though only in trifling quantities, in all.

**Hydrated Silicates with Bases  $R_2O_3$ .** **Clay.**—Leonhardt(1) has analysed, under Rammelsberg's direction, the yellowish-brown clay out of which the hot springs come at Natchiska in Kamskatka. On the digestion of it in hydrochloric acid there remains behind 64.37 per cent undissolved. No. I is the analysis of the soluble; No. II of the insoluble part.

	$SiO_3$ .	$Al_2O_3$ .	$Fe_2O_3$ .	CaO.	MgO.	HO.	Total.
I.	—	8.64	8.23	1.51	0.84	17.03	36.25
II.	51.41	8.76	4.60	1.09	0.06	—	65.92

**Halloysite.**—An amorphous white mass with a greasy feel, belonging to halloysite from a manganese-vein at Rumpelsberg near Elgersburg, was analysed in Rammelsberg's(2) laboratory, and gave nearly the composition of kaolin  $3 Al_2O_3, 4 SiO_3 + 6 HO$ .

$SiO_3$ .	$Al_2O_3$ .	CaO, MgO.	HO.	Total.
47.33	40.23	1.44	12.36	101.36

(1) Rammelsb. Handw., 4. Suppl., 222.

(2) Ibid., 214.

**Allophane.**

**Allophane.**—Schnabel(1) has investigated an allophane, varying from white to green in colour, and remarkable for its high amount of oxide of copper, of sp. gr. 2·02, from the siliceous slate, of Guldhausen (Anal. I and II); and B. Silliman, jun.,(2) has investigated the allophane, which incrusts the gibbsite (see this) at Richmond, (Anal. III). The latter formed translucent, but sometimes perfectly transparent, and colourless glassy incrustations, of scaly, leaflike structure.

	SiO <sub>3</sub> .	Al <sub>2</sub> O <sub>3</sub> .	MgO.	CuO.	HO.	Total.
I.*	24·19	25·80	—	13·71	35·49	99·19
II.*	19·41	26·77	—	18·97	34·72	99·87
III.	22·65	38·76	2·83	—	35·24	99·48

\* With traces of sesquioxide of iron and carbonic acid.

Rammelsberg pointed out, that the allophane of Guldhausen may be looked on as a mixture of 3 Al<sub>2</sub>O<sub>3</sub>, 2 SiO<sub>2</sub> + 15 HO with 3 CuO, SiO<sub>3</sub> + 12 HO. For the allophane of Richmond, Silliman, after abstracting the magnesia, calculates the former formula previous established by Gerhardt, for the allophane of Gräfenenthal.

**Smectite.**—Jordan(3) has analysed the smectite of Cilly, in Lower Styria(4). This is also found, according to Jordan, at Zeng, in Croatia.

SiO <sub>3</sub> .	Al <sub>2</sub> O <sub>3</sub> .	Fe <sub>2</sub> O <sub>3</sub> .	MgO.	CaO.	HO.	Total.
51·21	12·25	2·07	4·89	2·13	27·89	100·44

Rammelsberg took the iron to be protoxide, and gave the formula: 3 (RO, SiO<sub>3</sub>) + 2 (R<sub>2</sub>O<sub>3</sub>, 3 SiO<sub>3</sub>) + 25 HO.

**Monrolite.**—B. Silliman, jun., has given the provisional(5) name of monrolite to a mineral similar to wöerthite, and probably identical with it, from Monroe, Orange County, in New York, where it occurs in quartz with felspar, mica, pinite, and magnetic iron. It is found in green or grayish-green concentric radiated groups, but also in single crystals, which in form and cleavage are like sillimanite, but from the unevenness of the planes cannot be measured. Their hardness is = 7·25, in the cleavage-planes only = 6. Its sp. gr. is = 3·076 to 3·09. Heated in a glass tube the mineral gives off water.—Before the blow-pipe it does not melt.—The analysis gave :

	SiO <sub>3</sub> .	Al <sub>2</sub> O <sub>3</sub> .	MgO.	HO.	Total.
I.	40·92	56·61	0·28	3·09	100·90
II.	40·38	55·73	0·28	1·84	98·23
III.	40·38	56·81	0·28	2·79	100·26

(1) Rammelsb. Handw., 4. Suppl., 270.

(2) Sill. Am. J. [2] VII, 416.

(3) Pogg. Ann. LXXVII, 591; Rammelsb. Handw., 4. Suppl., 206 (in abstr.)

(4) See Breithaupt's Handb. d. Min. II, 344.

(5) Sill. Am. J. [2] VIII, 385; Phil. Mag. [3] XXXV, 458 (in abstr.); J. Pr. Chem. XLIX, 202.

Silliman calculated from this the formula  $8 (Al_2O_3, SiO_3) + 2 Al_2O_3$ , **Monocelite.**  
 3 HO, which demands 40.59  $SiO_3$ , 56.44  $Al_2O_3$ , and 2.97 HO.

**Pyrophyllite.**—Sjögren(1) has analysed, in Berlin's laboratory, pyrophyllite, from the abandoned iron mine of Westanå, in Schon, where it occurs with iron mica in a quartz vein. The sp. gr. was found to be = 2.78 to 2.79. For the analysis the mineral was dried over sulphuric acid.

	$SiO_3$ .	$Al_2O_3$ .	$Fe_2O_3$ .	MnO.	CaO.	MgO.	HO.	Total.
I.	67.77	25.17	0.82	0.50	0.66	0.26	5.82	101.00
II.	65.61	26.09	0.70	0.09	0.69	0.09	7.08	100.35

Three other experiments gave the proportion of water contained in it as = 5.62, 5.77, and 7.29 per cent.—After deducting the lime, the magnesia, and the protoxide of manganese, as bisilicates, the analysis conducts to the formula established by Rammelsberg  $2 Al_2O_3, 5 SiO_3 + 2 HO(2)$ .

**Hydrated Silicates with Bases RO. Meerschaum.**—According to L. Smith(3), the so highly valued meerschaum, from the Plain of Eskihi-sheer, in Asia Minor, occurs in more or less rounded masses, under the pebbles rolled from the neighbouring mountains, which consist of magnesia and hornblende rocks. He found in serpentine some veins of almost pure carbonate of magnesia, which did not occur under the pebbles in the plain, and conceives that the meerschaum is a product of decomposition of the carbonate of magnesia, through the action of the silicic acid held in solution by the water. He found meerschaum which still effervesced with acids, and other specimens to which the serpentine still adhered.(4)

**Hydrated Silicates with Bases  $R_2O_3$  and RO. Stilbite.**—Hermann(5) has analysed a stilbite less brilliant than usual, of sp. gr. 2.19, from the Ilmen Mountains, near Miask (I); Sjögren(6) has analysed two varieties of this zeolite, the one from Gustavsberg, in Jemtland (II), the other (III) from the Barbro Mine, in Norway. The two last were dried at  $100^\circ$ .

	$SiO_3$ .	$Al_2O_3$ .	$Fe_2O_3$ .	$FeO$ .	MnO.	CaO.	NaO.	HO.	Total.
I.	56.31	16.25	—	1.00		7.66	1.03	17.75	100.00
II.	57.41	16.14	0.25	—	—	8.75	—	16.60	99.15
III.	58.41	16.56	—	—	—	7.89	0.54*	16.53	99.93

\* Alkalies, together with magnesia and protoxide of manganese.

Sjögren reminds us that all previous analyses of stilbite gave an excess of water. He attributes it to this, that the mineral,

(1) Pogg. Ann. LXXVIII, 414.

(2) Rammelsb. Handw., 3. Suppl., 101.

(3) Sill. Am. J. [2] VII, 286.

(4) See Bischof's Chem. und Phys. Geologie, I, from 777 to 782.

(5) J. Pr. Chem. XLVI, 243; Rammelsb. Handw., 4. Suppl., 215 (in abstr.)

(6) Pogg. Ann. LXXVIII, 415.

Hydrated  
silicates  
with  
bases  
 $R_2O_3$   
and  
RO.  
Stilbite.

when dried over sulphuric acid, retains its hygroscopic water, which can only be expelled at  $100^\circ$ .—In three specimens of stilbite, dried over sulphuric acid, 18.40, 18.10 and 18.02 per cent of water were found, while that dried at  $100^\circ$  gave 16.80, 16.61 and 16.53 per cent.

**Laumontite.**—Sjögren(1) has also analysed a red zeolite, externally like ædelforsite, from Mora Stenar, in the neighbourhood of Upsala, and proved it to be the same as laumontite.

$SiO_2$ .	$Al_2O_3$ .	$Fe_2O_3$ .	CaO.	HO.	Total.
51.61	19.06	2.96	12.53	14.02	100.18

Sjögren is of the opinion that all the minerals analysed under the designation of red zeolite, mehlzeolite and ædelforsite are laumontite in more or less pure forms.

**Stellite and Pectolite.**—Dana(2) had stated it as his opinion that the stellite from Bergen Hill is identical with pectolite, on account of their external properties being identical. The correctness of this opinion is established by the following analyses: The analyses I. and II. of pectolite from Royal Island, in Lake Superior, were made by Whitney(3); the analyses III. and IV. of stellite were made, under his direction, by Kendall and Dickinson.

	$SiO_2$ .	CaO.	NaO.	$Al_2O_3$ .	HO.	Total.
I.	53.45	31.21	7.37	4.94	2.72	99.69
II.	55.66	32.86	7.31	1.45	2.72	100.00
III.	54.00	32.10	8.89	1.90	2.96	99.85
IV.	55.00	32.53	9.72	1.10	2.75	101.10

\* Together with traces of potassa in I. and II.

**Milnite and Agalmatolite.**—Hutzelmann and Karafiat(4), at the inducement of Haidinger, have investigated the amorphous clayey mass, enveloped in which the diaspore occurs at Schemnitz. There are three varieties of it. The first (I), called pinclite, at Schemnitz, possesses a splintery fracture, has a fatty lustre, is somewhat translucent, gray or greenish, with hardness = 2.5 to 3, and of sp. gr. 2.735. The second variety (II), called at Schemnitz bildstein, is white, opaque, dull, of flat conchoidal to uneven fracture, of hardness 3.5, and of 2.855 sp. gr. It adheres slightly to the tongue. The third variety (III), called at Schemnitz collyrite, is also white, opaque and dull, but earthy, and sticking strongly to the tongue. Its hardness is = 1.8 to 2, its sp. gr. = 2.574.—Nos. I. and III. were investigated by Karafiat. Hutzelmann analysed No. II.

(1) Pogg. Ann. LXXVIII, 415.

(2) Dana's System of Mineralogy, 2nd Edit., 336.

(3) Journ. Bost. Soc. Nat. Hist. 1849, 36; Sill. Am. J. [2] VII, 434 (in abstr.)

(4) Haidinger's Berichte über die Mittheilungen von Freunden der Naturwissenschaften, VI, 55; Pogg. Ann. LXXVIII, 575.

	$SiO_2$	$Al_2O_3$	$CaO$	$MgO$	$FeO$	$KO$ and $NaO$	$HO$	Total.	Dillnite and agalmatolite.
I.	49.50	27.45	5.56	0.72	1.03	10.20	5.10	99.56	
II.	22.40	56.40	trace	0.44	trace	trace	21.13	100.37	
III.	23.53	53.00	0.88	1.76	—	—	20.05	99.22	

The variety I. Haidinger declared to be agalmatolite, with which it was identical, as well in external properties as in regard to its composition (according to Thompson's(1) analysis).—The variety III. Haidinger treated as new, and distinguished it by the name of dillnite, from its locality, Dilln, not far from Schemnitz. It had, according to Haidinger's calculation, the formula  $2 Al_2O_3, SiO_3 + 4 HO$ .—No. II. is, in his opinion, also dillnite, but in mixture with a hydrate of alumina of the formula  $Al_2O_3, 4 HO$ , which in No. III. had been separated in the form of diasporite and of water. In fact, the diasporite occurs chiefly in No. III.

**Pinite.**—Rammelsberg(2) has analysed the pinite of St. Pardoux.

$SiO_2$	$Al_2O_3$	$Fe_2O_3$	$MnO$	$MgO$	$CaO$	$KO$	$HO$	Total.
48.92	32.29	3.49	0.11	1.30	0.51	9.14	4.27	100.03

**Palagonite.**—F. Sandberger(3) has recognised as palagonite a mineral distinguished by Stiff(4) as pitchstone, from Beselicher Kopf, near Obertiefenbach, not far from Limburg. It is very like that from Iceland(5). The fine powder of it suspended in water is decomposed by hydrosulphuric acid, with the formation of metallic sulphides. Its sp. gr. was found = 2.409. An analysis(6) gave the following composition:

$SiO_2$	$Al_2O_3$	$Fe_2O_3$	$CaO$	$MgO$	$KO$	$NaO$	$HO$	Insoluble matter.	Total.
47.856	9.718	10.305	4.869	2.974	0.811	1.019	20.202	2.096	99.850

with traces of sesquioxide of manganese.—Part of the silicic acid is mixed with the mineral, in the form of earthy opal. This could not be previously separated.

**Hisingerite.**—Hermann(7) has analysed hisingerite (gillingite) from a new locality, near Orijervi, in Finland, where it occurs in amorphous masses, and as a stalactitic incrustation with magnetic pyrites, iron pyrites, copper pyrites and lead-glance. The mineral is jet-black, but the powder is greenish-gray. In the fracture it is dull, but acquires a lustre by friction. Its sp. gr. is = 2.791. By concentrated hydrochloric acid it is easily decomposed. The analysis gave:

- (1) Thomson Outl. I, 343; Rammelsb. Handw., I, 6.  
 (2) Rammelsb. Handw., 4. Suppl., 178.  
 (3) Sandberger's Uebersicht d. Geologischen Verhältnisse von Nassau, 1847, 81.  
 (4) See Stiff's Geogn. Beschreibung v. Nassau (1831), 245.  
 (5) See Annual Report for 1847 and 1848, II, 419.  
 (6) Jahrb. d. Vereins für Naturk. im Herzogth. Nassau, 1849, 4 Heft, 227; J. Pr. Chem. XLVII, 463 (in abstr.)  
 (7) J. Pr. Chem. XLVI, 239; see Annual Report for 1847 and 1848, II, 420.



Hisingerite.

SiO <sub>2</sub> .	Fe <sub>2</sub> O <sub>3</sub> .	FeO.	MgO.	HO.	Total.
29.51	10.74	37.49	7.78	13.00	98.52

Hermann deduced from this the formula  $6 (2 \text{RO}, \text{SiO}_2) + \text{Fe}_2\text{O}_3$ ,  $2 \text{SiO}_2 + 12 \text{HO}$ . Rammelsberg(1) assumes the oxygen-ratios of  $\text{SiO}_3 : \text{R}_2\text{O}_3 : \text{RO} : \text{HO}$  as  $= 27 : 6 : 21 : 21$ , which concur with the formula  $7 (3 \text{FeO}, \text{SiO}_3) + 2 (\text{Fe}_2\text{O}_3, \text{SiO}_3) + 21 \text{HO}$ .

**Algerite.**—By the name algerite, T. S. Hunt(2) designated a mineral very like chondrodite, discovered by Alger at Franklin, in New Jersey, which occurs there in crystals, often 2 inches long and  $\frac{1}{8}$  inch thick, and sometimes curved, enclosed in a crystalline limestone. According to Hunt's very confused description, it occurs in rhombic prisms, imperfect at the ends, with angles of about  $94^\circ$ , and with the edges often replaced. In the direction of  $\infty \text{P}$ , and in that of  $\text{OP}$  they have indistinct cleavages, and belong, according to the oblique position of this last cleavage, to the monoclinometric system. Externally they are dull, but within have a vitreous lustre, with a tendency to a pearly lustre; they are translucent and straw-yellow, rarely quite colourless. Their hardness is  $= 3$  to  $3.5$ , and their sp. gr.  $= 2.697$  to  $2.712$ . In a glass tube the mineral gives much water. Before the blow-pipe it swells up very much, and melts to a blistering enamel. Hydrochloric acid decomposes it, but not entirely. The analysis gave:

SiO <sub>2</sub> .	Al <sub>2</sub> O <sub>3</sub> .	Fe <sub>2</sub> O <sub>3</sub> .	MgO.	KO.	NaO.	HO.	CaO.	CO <sub>2</sub>	Total.
49.82	24.91	1.85	1.15	10.21	trace	7.57	2.20	1.74	99.45

After deducting the lime and carbonic acid, as arising from an admixture of the limestone, it gives the oxygen-ratios of  $\text{RO} : \text{R}_2\text{O}_3 : \text{SiO}_3 : \text{HO} = 1 : 5.57 : 12.08 : 3.08 = 1 : 6 : 12.3$ , from which the formula follows of  $\text{KO}, \text{SiO}_3 + 2 \text{Al}_2\text{O}_3, 3 \text{SiO}_3 + 3 \text{HO}$ .

**Unionite.**—By the name of unionite, B. Silliman, jun.,(3) has designated a mineral, like scapolite and spodumene, which occurs at Unionville, in Pennsylvania, intimately intermixed with euphyllite, in black tourmaline. It possesses one indistinct, and two decided cleavages, from which it seems to be triclinometric. The colour is yellowish-white, the lustre vitreous, the hardness  $= 6$  to  $6.5$ , the sp. gr.  $3.298$ . The mineral is brittle, and admits of being easily pulverised.—In a glass tube it gives off water and hydrofluoric acid.—Before the blow-pipe it melts with intumescence, and a brilliant glow to a white enamel. By acids it is not gelatinised. The analysis gave:

SiO <sub>2</sub> .	Al <sub>2</sub> O <sub>3</sub> .	MgO.	NaO.	H <sub>2</sub> O and HFl.	Total.
44.151	42.263	7.361	1.731	3.522	99.028

(1) Rammelsb. Handw., 4. Suppl., 101.

(2) Sill. Am. J. [2] VIII, 103.

(3) Sill. Am. J. [2] VIII, 384; Phil. Mag. [3] XXXV, 457 (in abstr.); J. Pr. Chem. XLIX, 201

The ratios of the oxygen of  $RO : R_2O_3 : SiO_3 : HO$  were  $= 1 : 5.87 : 6.96 : 0.93 = 1 : 6 : 7 : 1$ , from which Silliman constructed the formula  $3 RO, SiO_3 + 6 (R_2O_3, SiO_3) + 3 HO$ . Unionite.

**Tritomite.**—N. J. Berlin(1) has investigated a mineral, found by Weibye, in the syenite of the Island of Lamö, near Brewig, in Norway, and described as tritomite. It crystallises in dark-brown tetrahedra of 4.16 to 4.66 sp. gr. In a glass tube it gives off water with a little fluorine. Before the blow-pipe it flies in pieces often with vehemence, intumescs, and burns white. With borax it dissolves to a clear bead, reddish-yellow when hot, and nearly colourless when cold.—Hydrochloric acid completely decomposes the pulverised mineral with evolution of chlorine, and separation of gelatinous silicic acid. Berlin would have the following results of analysis to be considered as only approximative, on account of the minute quantities of this rare mineral taken for the analysis.

$SiO_3$	$Al_2O_3$	$Ce_2O_3$	LaO.	YO.	CaO.	MgO.	FeO.	NaO.	Mn, Cu, Sn, W.	Loss on ignition.	Total.
20.13	2.24	40.36	15.11	0.46	5.15	0.22	1.83	1.46	4.62	7.86	99.44

**Silicates with Hydrates. Serpentine.**—Hermann(2) showed that the crystals of serpentine from Chursdorf, near Penig, in Saxony, agree with regard to their form, in the same way with chrysolite, as the crystals of serpentine from Snarum, if the prism, assumed by Haidinger(3) as longitudinal  $2\bar{P}\infty$ , is taken as vertical, and his transverse prism as a vertical prism  $\infty P$  and  $\infty \bar{P}2$ . Hermann thinks, with Tamnau and Scherer, that the crystals of serpentine are true crystals, and brings forward, as the proof of his opinion, that he had recently found in some places in the Ural crystals of serpentine, which looked quite fresh, and possessed perfect cleavage. In a variety from the Lake of Auschkal, near Miask, he determined six directions of cleavage, of which two, which intersect each other at right angles, correspond to the planes  $\infty \bar{P}\infty$  and  $\infty \bar{P}\infty$ ; two inclined at  $94^\circ 3'$  to each other, to the prism  $\infty \bar{P}2$ ; and the two last inclined to each other at  $71^\circ 10'$  to the prism  $\infty \bar{P}3$  of chrysolite.—This serpentine possesses pearly lustre on the cleavage-planes  $\infty \bar{P}\infty$ . Besides this it is transparent at the edges, and olive-green. Its hardness is 3.5, its sp. gr.  $= 2.57$ . It is easily decomposed by sulphuric acid when heated. Analysis gave:

$SiO_3$	$Al_2O_3$	FeO.	MgO.	HO.	Total.
40.21	1.82	9.13	35.09	13.75	100.00

(1) Rammelsb. Handw., 4. Suppl., 249; Pogg. Ann. LXXIX, 299.

(2) J. Pr. Chem. XLVI, 223; Rammelsb. Handw., 4. Suppl., 199 (in abstr.)

(3) Gilbert's Annalen, LXXV, 385.

Silicates  
with  
hydrates.  
Serpentine.

corresponding to the formula  $3\text{RO}, 2\text{SiO}_2 + 2\text{HO}$ , or  $2[(3\text{MgO}, 2\text{SiO}_3) + 3\text{HO}] + 3(\text{MgO}, \text{HO})(1)$ .

Hermann thinks, that schillerspar, from the Baste, in the Hartz and Villarsite, are also crystallised serpentine. The former because the angle of the cleavage is very nearly equal to that of  $\infty\check{P}\infty:\infty\check{P}2$  in chrysolite; the latter, because the angles of its prisms agree with those of chrysolite, if one takes the principal axis of villarsite, as brachydiagonal.

Schnabel(2) analysed serpentine from the Neuer Muth Mine, not far from Dillenburg, which is very soft, and of an olive-green colour. The mineral was first dried at  $100^\circ$ , whereby it lost 5.28 per cent water.

$\text{SiO}_3$ .	$\text{Al}_2\text{O}_3$ .	$\text{FeO}$ .	$\text{MgO}$ .	$\text{CaO}$ .	$\text{HO}$ .	Total.
41.70	7.04	26.95	10.26	3.34	11.58	100.87

**Marmolite.**—Hermann(3) found marmolite at Orijervi, in Finland, in hornblende rock; it is dense, in nodules, with flat conchoidal fracture, translucent at the edges, from bright leek-green to olive-green colour, and greenish-white streak. The fractured surfaces are dull, but acquire lustre by friction. Its hardness = 3, and sp. gr. = 2.44. Before the blow-pipe it glows strongly, but does not melt. Nitric acid decomposes it rapidly, but without effervescence. Analysis gave:

$\text{SiO}_3$ .	$\text{FeO}$ .	$\text{MgO}$ .	$\text{HO}$ .	Total.
40.00	1.80	42.40	15.80	100.00

Hermann establishes the oxygen-ratio of  $\text{RO}:\text{SiO}_3:\text{HO}=6:5:4$ , and considers this mineral, which is externally very much like serpentine, to be a different species. But if we calculate the oxygen-ratio from the bases, the above-mentioned ratio comes out =  $11.09:9:5.55$ , which might without hesitation be taken as =  $12:9:6$ , like that of serpentine.

**Epichlorite.**—Zincken has described more accurately, the mineral(4) which he discovered in the Radauthal, and which Rammelsberg analysed, and the latter has made a new analysis of it(5). It occurs in a hornfels quarry, in a dark leek-green, serpentine-like rock, in fragments composed of stem-like concretions with radiated structure. It divides prismatically with ease, possesses a remarkable fatty lustre, a dark leek-green colour, white streak, verging on green, and is in thin fragments, translucent, and of bottle-green colour. Its hardness is 2 to 2.5. Its sp. gr. = 2.76. In a flask it gives off

(1) See Annual Report for 1847 and 1848, II, 421.

(2) Rammelsb. Handw., 4. Suppl., 200.

(3) J. Pr. Chem. XLVI, 230; Rammelsb. Handw., 4. Suppl., 202 (in abstr.).

(4) See Annual Report for 1847 and 1848, II, 420.

(5) Pogg. Ann. LXXVII, 237; Rammelsb. Handw., 4. Suppl., 56 (in abstr.)

water, and before the blow-pipe it melts with great difficulty. It is only partially decomposed by hydrochloric acid.

Epichlorite.

$\text{SiO}_3$ .	$\text{Al}_2\text{O}_3$ .	$\text{Fe}_2\text{O}_3$ .	$\text{FeO}$ .	$\text{MgO}$ .	$\text{CaO}$ .	$\text{HO}$ .	Total.
40.88	10.96	8.72	8.96	20.00	0.68	10.18	100.38

Rammelsberg forms from this the formula  $3(3\text{RO}, \text{SiO}_3 + 2\text{R}_2\text{O}_3, 3\text{SiO}_3) + 9\text{HO}$ , or  $2[(3\text{RO}, 2\text{SiO}_3 + \text{R}_2\text{O}_3, \text{SiO}_3) + 3\text{HO}] + 3\text{MgO}, \text{HO}$ , according to which, this mineral would be chlorite, with a 1.5-fold proportion of silicic acid.

**Chlorite and Ripidolite.**—Rammelsberg(1) determined the relative proportion of sesquioxide of iron and protoxide of iron in ripidolite, from St. Gothard, as well as in the chlorites, from Schwarzenstein, and from Achmatowsk, according to Hermann's method of decomposition, by melting the minerals with borax in a platinum retort, closed so as to prevent the access of air, and treating the solution of the melted mass in dilute hydrochloric acid with terechloride of gold or metallic copper. Ripidolite gave by this means 16.89 per cent protoxide of iron. By introducing this value in Varrentrapp's(2) analysis of ripidolite, the latter gives the oxygen-ratio of  $\text{RO} : \text{R}_2\text{O}_3 : \text{SiO}_3 : \text{HO} = 9.5 : 10.6 : 12 : 7.3$ , which Rammelsberg, by comparing at the same time the analyses of Kobell(3) and Marignac(4), takes as  $= 9 : 9 : 12 : 9$ , and establishes from it the formula  $3(3\text{RO}, \text{SiO}_3) + 3\text{R}_2\text{O}_3, \text{SiO}_3 + 9\text{HO}$ . Chlorite from Schwarzenstein, gave 3.36 per cent sesquioxide of iron, and that from Achmatowsk, 4.55 of protoxide of iron, by which nothing is changed in the oxygen-ratio,  $10 : 6 : 12 : 8$ , established by Varrentrapp, for chlorite. But in order to bring the formula of chlorite in a more simple relation to the above-mentioned new formula of ripidolite, Rammelsberg changes the oxygen-ratio of chlorite into  $9 : 6 : 12 : 9$ , according to which, its formula would become  $= 3(3\text{RO}, \text{SiO}_3) + 2\text{R}_2\text{O}_3, \text{SiO}_3 + 9\text{HO}$ , and it would contain 1 equivalent of  $\text{R}_2\text{O}_3$  less than ripidolite.—In order to eliminate, moreover, this difference in the formulæ of these minerals, so like each other externally, Rammelsberg supposes, that in chlorite, alumina and silicic acid, substitute one another atom for atom, but in ripidolite in the ratio of 3:2, according to which these minerals would have the common formula  $3\text{RO}, 2(\text{SiO}_3, \text{Al}_2\text{O}_3) + 3\text{HO}$ . One must confess, that this method of bringing mineral species into more simple accordance, depends too much upon arbitrary assumption.—In the last Annual Report, II, p. 424, Varrentrapp's formula of chlorite is not rightly given. It ought to be  $3(\text{MgO}, \text{FeO}), \text{SiO}_3 + \text{Al}_2\text{O}_3, \text{SiO}_3 + 2(\text{MgO}, 2\text{HO})$ .

(1) Pogg. Ann. LXXVII, 414; Rammelsb. Handw., 4. Suppl., 34 (in abstr.)

(2) Pogg. Ann. XLVIII, 189.

(3) J. Pr. Chem. XVI, 470.

(4) Ann. Ch. Phys. [3] XIV, 56.

Ferru-  
ginous  
chlorite.

**Ferruginous Chlorite.**—Delesse(1) considers as a variety of chlorite, the finely-fibrous, dark blueish-green mineral, which occurs in the blister-cells of amygdaloid porphyry, from Oberstein, and from Planitz, near Zwickau.

	SiO <sub>3</sub> .	Al <sub>2</sub> O <sub>3</sub> .	Fe <sub>2</sub> O <sub>3</sub> .	FeO.	CaO.	MgO.	H <sub>2</sub> O.	Total.
I.	29.08	42.00	—	—	3.70	12.23*	12.99	100.00
II.	29.45	18.25	8.17	15.12	0.45	15.32	12.57	99.33

\* Determined from the loss.

**Steatite.**—Rammelsberg(2) analysed the so-called steatite, from the serpentine of Snarum, which had been already analysed by Hochstetter and Giwartowsky. It is a chlorite. Rammelsberg found:

SiO <sub>3</sub> .	Al <sub>2</sub> O <sub>3</sub> .	Fe <sub>2</sub> O <sub>3</sub> .	MgO.	H <sub>2</sub> O.	Total.
34.88	12.48	5.81	31.02	13.68	100.87

**Masonite.**—J. D. Whitney(3) found the following composition for Jackson's(4) masonite.

SiO <sub>3</sub> .	Al <sub>2</sub> O <sub>3</sub> .	FeO.	MgO.	H <sub>2</sub> O.	Total.
28.27	32.16	33.72	0.13	5.00	99.28.

The oxygen-ratio of RO : R<sub>2</sub>O<sub>3</sub> : SiO<sub>3</sub> : H<sub>2</sub>O is = 3 : 5.97 : 5.95 : 1.76. Whitney considers it = 3 : 6 : 6 : 2, and gives the formula 3 FeO, SiO<sub>3</sub> + 2 Al<sub>2</sub>O<sub>3</sub>, SiO<sub>3</sub> + 2 H<sub>2</sub>O, which differs from Bonsdorff's formula for chloritoid, only by this, that chloritoid gives 3 H<sub>2</sub>O.

Whitney thinks, that the mineral analysed by Bonsdorff, contained also only 2 equivalents of water, as analysis gave only 6.95 per cent, and considers therefore both minerals as identical.

**Silicates with Fluorides, Chlorides, Sulphates, Titanates, and Borates. Chondrodite.**—W. Fisher(5) obtained the following results on analysis of a strongly red-coloured chondrodite.

SiO <sub>3</sub> .	MgO.	Fe <sub>2</sub> O <sub>3</sub> .	Fl.	Total.
33.35	53.05	5.50	7.60	99.50

**Sodalite.**—Borck(6) analysed, under Berlin's direction, lavender-coloured sodalite, from the Island of Lamö, near Brewig, in Norway, which occurs there in the form of nodules or reniform masses, disseminated in clæolite, or incrusting it.

(1) Ann. Min. [4] XVI, 520; see Annual Report for 1847 and 1848, II, 424.

(2) Rammelsb. Handw., 4. Suppl., 37.

(3) Proc. Bost. Soc. Nat. Hist. 1849, 100; Sill. Am. J. [2] VIII, 272.

(4) Geol. Rep. of Rhode Island, 88; Dana's Syst. of Mineralogy, 2. Edit., 372; Rammelsb. Handw., 3. Suppl., 77 (the mineral in this place is called erroneously mazonite.)

(5) Sill. Am. J. [2] IX, 85.

(6) Pogg. Ann. LXXVIII, 413.

SiO <sub>3</sub> .	Al <sub>2</sub> O <sub>3</sub> .	NaO.	KO.	CaO.	MgO.	Total.	Sodalite.
38·86	30·82	22·03	0·51	1·21	0·44	93·87	

with traces of SnO<sub>2</sub>, MnO, WO<sub>3</sub>, and MoO<sub>3</sub>.—The chlorine was not determined.

**Skolopsite.**—Kobell(1) designated by the name of skolopsite a new mineral from Kaiserstuhl, in the Breisgau. It appears in smoke-gray, here and there pale reddish-white, granular pieces, which sometimes exhibit cleavage-planes, the direction of which, however, could not be made out.—Thin splinters of the mineral are translucent. Its hardness is nearly = 5, and its sp. gr. = 2·53. Before the blow-pipe it melts with frothing and spurting to a greenish-white bubbly glass. Melted with soda on charcoal it gives an alkaline sulphide. By hydrochloric acid the powder of the mineral is readily decomposed, as well before as after heating, with evolution of carbonic acid, after which nearly 5 per cent of a blackish-green powder remains, to which the mineral owes its dark colour. The solution contains sulphuric acid. By melting with hydrate of potassa, and by treating the aqueous solution with metallic silver, the presence of a small quantity of sulphur can be proved, as in hauyne. The result of analysis was, after subtracting the calc-spar and the insoluble residue, as follows :

SiO <sub>3</sub> .	Al <sub>2</sub> O <sub>3</sub> .	Fe <sub>2</sub> O <sub>3</sub> .*	MnO.	CaO.	MgO.	NaO.	KO.	SO <sub>3</sub> .	S.	NaCl.	Total.
44·06	17·86	2·49	0·86	15·48	2·23	11·54	1·30	4·09	trace	0·93	100·84

\* Together with some protoxide of iron.

The mineral therefore belongs, according to this, to hauyne, noseane, and ittnerite. In order to arrive at an idea of its atomic constitution, Kobell, starting from chloride of sodium, calculated the hypothetical amount of sodalite contained in the mineral(2), which turned out to be = 7·78 per cent. He established for the principal constituent of the mineral the formula NaO, SO<sub>3</sub> + 3 (3 RO, 2 SiO<sub>3</sub> + Al<sub>2</sub>O<sub>3</sub>, SiO<sub>3</sub>), and directs attention to this, that scolopsite admits of being regarded as a mixture of anhydrous glottalite and sodalite.

**Schorlamite.**—Shepard had described, together with arcansite, a black mineral, which accompanies it, called schorlamite(3). It occurs in amorphous as well as in rhombic (rhomboïdal ?) crystals, and contains, according to his investigation, silicic acid, yttria, thorina, sesquioxide of iron and water. He found its hardness = 7 to 7·5, and its sp. gr. = 3·862.

The same mineral has now been examined by Rammelsberg(4)

(1) Gelehrte Anzeigen der Königl. Bair. Akademie der Wissenschaften, 1849, No. 77 u. 78; J. Pr. Chem. XLVI, 484; Rammelsb. Handw., 4. Suppl., 204 (in abstr.)

(2) See Annual Report for 1847 and 1848, II, 425.

(3) Sill Am. J. [2] II, 250.

(4) Pogg. Ann. LXXVII, 123; Rammelsb. Handw., 4. Suppl., 196 (in abstr.)

Schorlomite.

and by Whitney(1), but with very different results to those obtained by Shepard.

According to Rammelsberg, the mineral has the hardness given by the latter. Its sp. gr. Rammelsberg determined to be = 3.862, Whitney = 3.807. Before the blow-pipe it melts, but with great difficulty, at the edges. No. I and II of the following analyses have been executed by Rammelsberg, No. III and IV by Whitney.

	SiO <sub>3</sub> .	TiO <sub>2</sub> .	Fe <sub>2</sub> O <sub>3</sub> .	FeO.	CaO.	MgO.	Total.
I.	27.85	15.32	—	23.75	32.01	1.52	100.45
II.	26.09	17.36	—	22.83	31.12	1.55	98.95
III.	27.89	20.43	21.90	—	30.05	—	100.27
IV.	25.66	22.10	21.58	—	29.78	—	99.12

The silicic acid in Analysis I and II still contained some titanitic acid.—Rammelsberg's and Whitney's analyses agree approximately in the amount of silicic acid and lime, but differ in other respects so much from each other, that one might almost think that an error occurred in the determination of the degree of oxidation of the iron, if the analyses did not differ also in regard to the titanitic acid.—Rammelsberg gives the formula  $2(3\text{RO}, 2\text{SiO}_3) + 3(2\text{RO}, \text{TiO}_3)$ , Whitney, the formula  $(3\text{CaO}, \text{SiO}_3 + \text{Fe}_2\text{O}_3, \text{SiO}_3) + \text{CaO}, 2\text{TiO}_3$ , in which the first member is melanite, in company with which the mineral occurs.

**Datolite.**—According to Haidinger(2), S. v. Helmreich has discovered in the serpentine mountains, near Toggia, at the Dragone, in Modena, very beautiful crystals of datolite, sometimes  $\frac{1}{2}$  an inch in size, perfectly transparent, colourless, with smooth planes. Their form is in general that of datolite from the amygdaloid of the Theiss. A drawing communicated by him represents a crystal determined by Hauer, on which, besides the forms already known  $OP$ . ( $P\infty$ ).— $2P\infty$ .— $P.2P2.4P4.5P5.\infty P.\infty P2.\infty P\infty$ , a prism  $\infty P3$ , not till now observed, occurs. The hemi-pyramid  $5P5$  had not been determined exactly before Hauer's measurement of this crystal.

**Arsenates. Arsenate of Zinc.**—O. Köttig(3) examined a white to peach-blossom red, translucent incrustation, on green-stone, containing zincblende, from the deserted Daniel Mine, near Freiberg. It possesses a distinct crystalline prismatic structure, and pearly vitreous lustre. Hardness = 3, and sp. gr. 3.1. Köttig observed also delicate crystals, which according to Naumann's(4) investigation, are very like those of cobalt bloom, and have a very well marked cleavage in the direction of the planes ( $\infty P\infty$ ). Before the

(1) Journ. Bost. Nat. Hist. Soc. 1849, 42; Sill. Am. J. [2] VII, 433 (in abstr.), in this place the mineral is called schorlomite.

(2) Wien. Acad. Ber. 1849, März, 215; Pogg. Ann. LXXVIII, 75.

(3) J. Pr. Chem. XLVIII, 183.

(4) Ibid. 256.

blowpipe on charcoal the mineral melts to a bead, and is afterwards absorbed by the charcoal with the formation of arsenious vapour and a zinc coating. A preliminary analysis(I), in which the arsenic acid was not determined directly, showed that the composition of the mineral is analogous to that of cobalt bloom.

Arse-  
nates.  
Arsenate  
of zinc.

	AsO <sub>5</sub> .	ZnO.	CoO.	NiO.	H <sub>2</sub> O.	Total.
I.	37.17	30.52	6.91	2.00	23.40	100.00
II.	37.24	39.44	—	—	23.32	100.00

No. II. is the percentage composition calculated according to the formula  $3(\text{ZnO}, \text{AsO}_5) + 8 \text{H}_2\text{O}$ .

**Konichalcite.**—A mineral, like malachite, in the Freiberg collection, recognised by Breithaupt as new, from Hinojosa de Cordova, in Andalusia, has been analysed by W. Fritzsche(1). It is reniform, of a splintery fracture inclining to fine granular, translucent on the edges, vitreous in lustre, and of a colour between pistachio-green and emerald green. Its hardness is 5.25 to 5.75 (= 4.5 according to Mohs), sp. gr. = 4.123. In the analysis were obtained :

	AsO <sub>5</sub> .	PO <sub>5</sub> .	VO <sub>5</sub> .	CuO.	CaO.	H <sub>2</sub> O.	Total.
I.	30.68	8.81*	1.78	31.76	21.36	5.61	100.00
II.	32.41	—	—	31.60	21.82	5.30	—
III.	—	9.10	—	—	22.10	5.56	—
Average	31.54	8.95	1.78	31.68	21.76	5.49	101.20

\* Determined from the loss.

Instead of the formula proposed by Fritzsche  $2(3 \text{CuO}, \text{AsO}_5 + 6 \text{CaO}, \text{PO}_5) + 5 \text{H}_2\text{O}$ , which assumes that the two isomorphous acids exist in different degrees of saturation, Rammelsberg establishes the formula  $2[4(\text{CuO}, \text{CaO}), (\text{AsO}_5, \text{PO}_5)] + 3 \text{H}_2\text{O}$ , in which the vanadic acid is taken =  $\text{VO}_5$ .(2)

**Phosphates. Pyromorphite.**—F. Sandberger(3) analysed a crystallised light green pyromorphite of 7.1 sp. gr., from Cransberg, (I), and crystallised wax-yellow pyromorphite, from Ems (II).

	PbO.	PO <sub>5</sub> .	Cl.	Total.
I.	81.622	15.942	2.669	100.233
II.	82.203	15.960	2.790	100.953

Both these analyses correspond exactly to the known formula  $3(3 \text{PbO}, \text{PO}_5) + \text{PbCl}$ .

**Ferruginous Apatite.**—The mineral from Bodenmais, designated by Fuchs by the name of ferruginous apatite, has been analysed by Rammelsberg(4).

(1) Pogg. Ann. LXXVII, 139.

(2) Rammelsb. Handw., 4. Suppl., 120.

(3) Jahrb. d. Vereins f. Naturk. im Herzogthum Nassau, 1849, 226; J. Pr. Chem. XLVII, 462 (in abstr.)

(4) Rammelsb. Handw., 4. Suppl., 247.



Iron  
apatite.

	PO <sub>5</sub> .	FeO.	MnO.	Fl.	Total.
I.	30.03	41.42	23.25	6.00	101.00
II.	—	40.90	24.33	—	—

Rammelsberg calculates from this the formula  $3\text{RO}, \text{PO}_5 + \text{RFl}$ , for which the analysis gave 2.26 per cent fluorine too little, but which arises from this, that we have not yet any exact method of determining it.

**Phosphocerite. (Cryptolite.)**—H. Watts(1) has examined the grayish-yellow crystalline powder, which O. Sims found remaining, after treating the roasted cobalt-ore (glance cobalt), from Johannisberg, in Sweden, with hydrochloric acid, and which is about 0.001 of the ore. Under the microscope opaque, dark-red, regular octahedra, and combinations of this with rhombic dodecahedra, which can be extracted by the magnet, and are soluble in hydrochloric acid, can be distinguished; they contain both degrees of oxidation of iron with the protoxide of cobalt. The powder consists principally of yellow, square pyramids, or combinations of these with a prism, in hardness between 5 and 5.25, and sp. gr. 4.78. These are insoluble in hydrochloric and nitric acid, but are completely decomposed by sulphuric acid. Their analysis executed in Graham's laboratory, gave:

PO <sub>5</sub> .	CeO.	LaO.	DO.	Fe <sub>2</sub> O <sub>3</sub> .	CoO.	Sand.	Total.
28.46		64.68		2.91	0.45	2.96	92.46

Watts considers the iron in the mineral, without adducing his reasons, as magnetic oxide. If we view it as protoxide, the oxygen-ratio comes out  $\text{PO}_5 : \text{RO} = 5 : 3.18$ , and the formula  $= 3\text{RO}, \text{PO}_5$ , which Wöhler established for cryptolite(2), with which the mineral also agrees in colour and sp. gr. However, Watts thinks that his mineral, which he calls phosphocerite, is a species distinct from cryptolite, because the latter presents hexagonal prisms, the phosphocerite however square ones. According to Chapman(3) both could also belong to the rhombic or monoclinometric system, but this cannot be made out with exactness, on account of the small size of the crystals.

**Triphylline.**—Baer(4) analysed the triphylline from Bodenmais. It dissolves in acids even after heating, by which it is rendered brown.

PO <sub>5</sub> .	FeO.	MnO.	CaO.	MgO.	KO.	NaO.	LiO.	SiO <sub>3</sub> .	Total.
36.36	44.52	5.76	1.00	0.73	1.19	5.16	5.09	1.78	100.59

(1) Chem. Soc. Qu. J. II, 131.

(2) Berzelius' Jahresber. XXVI, 336; Göttinger gel. Anz. 1846, 19.

(3) Chem. Soc. Qu. J. II, 154.

(4) Arch. Pharm. [2] LVII, 274; J. Pr. Chem. XLVII, 462 (in abstr.)

If we take the oxygen of the phosphoric acid = 5, that of the bases will be 3.985, and consequently will be too much by 0.985 for the formula of triphylline  $3\text{RO}, \text{PO}_5$ ; but the analysis corresponds to this exactly, if we suppose that the mineral contains a silicate of the formula  $3\text{RO}, \text{SiO}_3$  mixed with it.

**Vivianite.**—W. Fisher(1) analysed vivianite, which occurs in free colourless transparent crystals, in the green sand of the Delaware, not far from Cantwells Bridge. Exposed to the air it becomes, in the course of some weeks, of a light green, without losing its transparency.

$\text{PO}_5$ .	$\text{FeO}$ .	$\text{H}_2\text{O}$ .	$\text{SiO}_3$ .	Total.
27.17	44.10	27.95	0.10	99.32.

**Dufrenite.**—Schnabel(2) analysed concentric fibres of dufrenite, containing dark leek-green and brown points, from Hollerter Zug, near Siegen.

$\text{PO}_5$ .	$\text{Fe}_2\text{O}_3$ .	$\text{FeO}$ .	$\text{H}_2\text{O}$ .	Total.
28.39	53.66	9.97	8.97	100.99

Rammelsberg calculates from this the formula  $4\text{FeO}, \text{PO}_5 + 5(2\text{Fe}_2\text{O}_3, \text{PO}_5) + 14\text{HO}$ , but imagines that the original composition has been  $2(4\text{FeO}, \text{PO}_5) + 5\text{H}_2\text{O}$ , which if we subtract the water is the composition of the triphylite from Limoges, and according to his opinion also the original composition of the heterosite from the same locality.

**Stercorite.**—Th. J. Herapath(3) examined a yellowish-brown, transparent salt, which was found in broad crystalline masses or nodules, in a cargo of guano, from the Island of Ichaboc, on the west coast of Africa. The analysis showed, that it is phosphate of soda-ammonia of the known composition  $(\text{NaO}, \text{NH}_4\text{O}, \text{H}_2\text{O}), \text{PO}_5 + 8\text{H}_2\text{O}$ , rendered impure by 8.4 per cent of carbonate of lime, carbonate of magnesia, phosphate of lime, sand, and organic matter. Its sp. gr. = 1.615. Herapath designates this salt by the name of stercorite.

Herapath found, in the same guano, the phosphate of ammonia which Tschchemacher(4) discovered in guano. After purifying it by recrystallisation, an analysis gave 52.962 per cent phosphoric acid, 23.980 ammonia, and 23.058 water, which corresponds nearly to the formula  $3\text{NH}_4\text{O}, \text{PO}_5$ .

**Gibbsite.**—Hermann(5) has analysed gibbsite, from Richmond, in Massachusetts(6), repeatedly, and B. Silliman, jun.(7), has also made

(1) Sill. Am. J. [2] IX, 83.

(2) Rammelsb. Handw., 4. Suppl., 87.

(3) Chem. Soc. Qu. J. II, 70; Sill. Am. J. [2] VIII, 129.

(4) Mem. Chem. Soc. III, Part XVI, 13.

(5) J. Pr. Chem. XLVII, 1; Rammelsb. Handw., 4. Suppl., 72 (in abstr.)

(6) See Annual Report for 1847 and 1848, II, 439.

(7) Sill. Am. J. [2] VII, 411.

Gibbsite.

some analyses of it. Hermann took for his analyses laminated gibbsite of 2.21 sp. gr. (I), stalactitic of 2.44 sp. gr. (II), and earthy of 2.20 sp. gr. (III). The gibbsite used for Silliman's analyses (IV, V, VI) formed stalactites of radiated fibrous structure, or amorphous incrustations on brown hematite, here and there coated with pearl-white allophane, see p. 534. Its hardness was 3.5. Its sp. gr. 2.389. It was only partially decomposed by hydrochloric acid, but completely by sulphuric acid. Solution of potass dissolved it easily.

	Al <sub>2</sub> O <sub>3</sub> .	PO <sub>5</sub> .	HO.	MgO.	Insoluble portion.	Total.
I a.	26.66	37.62	35.72	—	—	100.00
I b.	38.29	26.30	35.41	—	—	100.00
II.	50.20	15.30	34.50	—	—	100.00
III.	53.92	11.90	34.18	—	—	100.00
IV.	63.44	—	34.48	0.30	1.78	100.00
V.	64.96	0.59	34.07	0.30	0.08	100.00
VI.	64.16	trace	34.15	0.30	1.62	100.23

In Analyses IV., V. and VI., the amount of water is determined by the loss. Direct determinations gave it from 35.20 to 33.82, and 33.42 per cent.—Silliman's analyses prove the correctness of the formula  $\text{Al}_2\text{O}_3 + 3 \text{HO}$ , calculated from the analyses of Torrey, Thomson, and Dewey. Hermann's specimens were clearly mixtures of this hydrate of alumina with phosphate of alumina  $\text{Al}_2\text{O}_3, \text{PO}_5 + 8 \text{HO}$ , found by him in his first analyses.—The name of gibbsite might be retained for the latter, the name of hydrargyllite for the hydrate of alumina.

**Sulphates.** **Celestine.**—Leonhardt(1) analysed, under Rammelsberg's direction, a reddish-white, concentric, radiated celestine, from the Thieder Berg, near Brunswick.

SO <sub>3</sub> .	SrO.	CaO.	Fe <sub>2</sub> O <sub>3</sub> .	Loss on ignition.	Insoluble portion.	Total.
41.23	53.90	1.12	1.88	0.49	0.94	99.56

**Brogniartine.**—Ulex(2) found crystals of brogniartine from 1 to 1½ inch in size, in American nitre. They possessed the hardness 2.5 to 3, a sp. gr. of 2.64, and according to Frankenheim's measurement the same angles as were given by Naumann and Phillips.—The analysis gave :

SO <sub>3</sub> .	BO <sub>3</sub> .	CaO.	NaO.	Total.
55.0	3.5	19.6	21.9	100.00

According to Ulex the boracic acid comes from the boronatro-calcite mixed with it; but there are bases wanting to form this salt.

(1) Rammelsb. Handw., 4. Suppl., 39.

(2) Ann. Ch. Pharm. LXX, 51; Rammelsb. Handw., 4. Suppl., 73 (in abstr.)

**Gypsum.**—De la Trobe(1) analysed gypsum, of pumice-like, porous, and fibrous texture, from the Volcano of Albay, on the Island of Luzon.

Gypsum.

SO <sub>3</sub> .	SiO <sub>3</sub> .	CaO.	Al <sub>2</sub> O <sub>3</sub> .	Fe <sub>2</sub> O <sub>3</sub> .	HO.	Total.
44.19	6.43	29.41	0.64		20.18	100.85

**Sulphate of Cobalt.**—Schnabel(2) analysed sulphate of cobalt, formed on the residue of the cobalt washing, from the Glückstern Mine, as well as an incrustation on pitchblende, from the Morgenröthe Mine, near Siegen, which may be mentioned here.

	SO <sub>3</sub> .	CoO.	CuO.	CaO.	MgO.	Cl.	HO.	Earthy residue.	Total.
1.	28.81	23.30	0.30	0.43	0.88	0.04	45.22	1.14	100.12
11.	20.84	16.50	0.44	trace	trace	0.05	38.13	24.04	100.00

**Carbonates.**—Concerning Sénarmont's production of the carbonates of magnesia, iron, manganese, and zinc, with similar properties as the native salts, see p.

**Acrusite.**—Schnabel(3) found a black coated crystal of carbonate of lead, from the Churfürst Ernst Mine, near Benkhausen, in Westphalia, composed of 83.93 per cent protoxide of lead, and 16.07 per cent carbonic acid.

**Strontianite.**—The radiated prismatic strontianite, from Hamm, on the Lippe, gave in an analysis executed by Schnabel(4), 91.71 per cent carbonate of strontia, and 7.89 per cent carbonate of lime, with a little silicic acid.

**Calcite.**—R. F. Marchand(5) examined the pseudomorph of calc-spar, in the form of gay-lussite, known under the name of calcite, from Obersdorf, near Sangerhausen.

CaO, CO <sub>2</sub> .	Al <sub>2</sub> O <sub>3</sub> and Fe <sub>2</sub> O <sub>3</sub> .	CaO, SO <sub>3</sub> .	H <sub>2</sub> O.	Residue.	Total.
94.37	1.15	2.02	1.34	1.10	99.98

**Calamine.**—A whitish-yellow, scaly, foliated zinc-ore, of 3.8 sp. gr., from the environs of Wiesloch, in Baden, gave on analysis, performed by E. Riegl(6) :

CO <sub>2</sub> .	ZnO.	Fe <sub>2</sub> O <sub>3</sub> .	CaO.	SiO <sub>3</sub> .	H <sub>2</sub> O and loss.	Total.
7.00	80.25	1.04	2.10	7.65	1.96	100.00

**Conite.**—H. Hirzel(6) analysed the conite from Frankenhayn, at the Meissner.

(1) Rammelsb. Handw., 4. Suppl., 89.

(2) Ibid. 119.

(3) Ibid. 260.

(4) Ibid. 215.

(5) J. Pr. Chem. XLVI, 95; Rammelsb. Handw., 4. Suppl., 31 (in abstr.)

(6) Arch. Pharm. [2] LVIII, 29.

(7) Arch. Pharm. [2] LIX, 154.

Conite.

CaO, CO <sub>2</sub> .	MgO, CO <sub>2</sub> .	FeO, CO <sub>2</sub> .	Total.
27.53	67.97	5.05	100.55
27.43	67.47	5.41	100.25

**Spathic-iron.**—Schnabel(1) analysed spathic-iron from the following mines in the district of Siegen:

I. Silberquelle, near Obersdorf; II. Alte Thasbach, near Eisersfeld; III. Stahlberg, near Müsen; IV. Samnerichskaule, near Horthausen; V. Vier Winde, near Bendorf; VI. Kux; VII. Stahlert; VIII. Bollenbach; IX. Guldenhardt; X. Hollerterzug; XI. Häuslingstiefe; XII. Andreas, near Hamm, on the Sieg; XIII. Kammer and Storch.

	FeO.	MnO.	CaO.	MgO.	CO <sub>2</sub> .	SiO <sub>3</sub> and loss
I.	50.91	9.04	0.40	0.80	37.84	1.01
II.	48.79	9.66	0.36	1.25	37.43	2.51
III.	47.16	10.61	0.50	3.23	38.50	—
IV.	48.91	8.66	0.32	1.94	37.62	2.54
V.	48.83	10.80	0.41	1.41	38.38	0.17
VI.	48.07	10.40	0.36	2.21	38.57	0.33
VII.	48.86	8.91	0.32	2.34	37.74	2.55
VIII.	46.97	7.56	0.46	2.22	36.15	5.74
IX.	50.56	9.67	0.16	1.16	38.27	0.08
X.	47.10	7.65	0.34	2.45	36.45	4.60
XI.	50.37	8.30	0.25	2.15	38.48	0.45
XII.	46.68	9.87	0.35	3.91	39.19	—
XIII.	49.41	9.52	—	0.94	37.11	0.32

Schnabel farthermore analysed a brownish-redspathic iron, much-weathered, from the Steigersberg Mine, near Tiefenbach, not far from Siegen.

Fe <sub>2</sub> O <sub>3</sub> .	FeO, CO <sub>2</sub> .	MnO, CO <sub>2</sub> .	CaO, CO <sub>2</sub> .	MgO, CO <sub>2</sub> .	SiO <sub>3</sub> .	HO.	Total.
38.83	32.19	8.48	2.68	9.45	3.24	5.71	98.58

**Bismuth-spar.**—Rammelsberg(2) gave the name of bismuth-spar to a white mineral similar to calamine, with a vitreous lustre and 7.67 sp. gr., which, according to Lieber, occurs in considerable quantities in the gold mines of Chesterfield County, in South Carolina.—Heated in a glass tube, it decrepitates, gives off water, becomes brownish-yellow, and easily melts into the glass. Before the blow-pipe on charcoal it is easily reduced to bismuth. In nitric acid it dissolves with effervescence, leaving behind a yellow clayey residue. Its analysis gave:

BiO <sub>3</sub> .	Fe <sub>2</sub> O <sub>3</sub> .	Al <sub>2</sub> O <sub>3</sub> .	CaO.	MgO.	CO <sub>2</sub> .	HO.	Insoluble portion.	Total.
82.63	0.52	0.16	0.28	0.07	6.02	3.16	6.98	99.82

After subtracting the inessential ingredients, the mineral gives the oxygen-ratio of BiO<sub>3</sub>:CO<sub>2</sub>:HO=3:1.5:1=6:3:2, from which

(1) Rammelsberg's Handw., 4. Suppl., 209.

(2) Pogg. Ann. LXXVI, 564; Rammelsb. Handw., 4. Suppl., 262 (in abstr.)

Rammelsberg establishes the formula  $3 (\text{BiO}_3, \text{CO}_2 + \text{HO}) + \text{BiO}_3, \text{HO}$ . He thinks it probable that this compound is contained in bismuth-ochre, and especially constitutes the principal ingredient of Breithaupt's bismuthite from Ullersreuth.

Bismuth-  
spar.

**Hydromagno-calcite. (Pennite).**—Hermann(1) designates by the name of pennite a mineral from Lancaster County, Pennsylvania, where it occurs in the form of a sinter-like coating on chrome-iron; externally it is grass-green, inside it is rose-red. Its hardness = 3·5, sp. gr. = 2·86. As the result of an analysis, Hermann obtained the following numbers:

CaO.	MgO.	FeO.	MnO.	NiO.	CO <sub>2</sub> .	HO.	Al <sub>2</sub> O <sub>3</sub> .	Total.
20·10	27·02	0·70	0·40	1·25	44·54	5·84	0·75	100·00

The-oxygen ratio of  $\text{RO} : \text{CO}_2 : \text{HO} = 3·26 : 6·24 : 1$ , from which Hermann establishes the formula  $3 (\text{MgO}, \text{CaO}, \text{NiO}), \text{CO}_2 + \text{HO}$ . Rammelsberg(2) proposes, instead of the name of pennite, which could be confounded with pennine, the name hydromagno-calcite.

**Borates. Tiza. Boronatro-calcite.**—Ulex(3) described a mineral which occurs in considerable quantity, accompanied by fragments of andesine and crystallised brongniartine (see p. 548) in layers of salt-petre in the south of Peru, where it is called tiza. It forms nodules of the size of a hazel-nut, and upwards, which closely resemble aluminite, and are inside finely fibrous, and of a silky lustre. There were observed also delicate, apparently hexagonal, prisms, but the angles of which were not measurable. Its sp. gr. = 1·8. Before the blow-pipe, the mineral melts easily to a clear pearl. In cold water it is scarcely soluble, in hot water with difficulty. Acids dissolve it easily. Analysis gave:

	BO <sub>3</sub> .	CaO.	NaO.	HO.	Total.
I.	49·5	15·7	8·8	26·0	100·0
II.	49·5	15·9	8·8	25·8	100·0

Ulex calculates from this the formula  $\text{NaO}, 2 \text{BO}_3 + 2 \text{CaO}, 3 \text{BO}_3 + 10 \text{HO}$ . He leaves it, with Rammelsberg(4), undetermined whether the mineral is identical or not with hydroboro-calcite, described by Hayes, from Iquique, in Peru, and which contained 35 per cent water.—The editors of the "Annalen der Chemie und Pharmacie" consider both minerals to be identical, and propose the name boronatrocalcite.

**Chlorides. Rock-salt.**—According to O. Henry(5), almost all rock-salt contains iodine. He states that the presence even of the

(1) J. Pr. Chem. XLVII, 13.

(2) Rammelsb. Handw., 4. Suppl., 109.

(3) Ann. Ch. Pharm. LXX, 51.

(4) Rammelsb. Handw., 4. Suppl., 108.

(5) J. Chim. Méd. [3] V, 81; J. Pr. Chem. XLVII, 231.

Chlo-  
rides.  
Rock-  
salt.

smallest quantity of it in the mother-liquor can be proved by the common means, if some solution of potassa be added to the solution of the salt, before evaporating, in order to prevent the sublimation of the iodine.

**Atacamite.**—Amongst the copper-ores recently brought directly from Valparaiso to Hamburg, Ulex(1) found conglomerates of crystals of atacamite, sometimes 2 lines in length, upon earthy red hematite. An analysis of them gave the following result :

CuO.	Cu.	Cl.	HO.	SiO <sub>2</sub> .	Total.
56.23	14.56	16.12	11.99	1.10	100.00

by which the correctness of the formula  $3(\text{CuO}, \text{HO}) + \text{CuCl}$  is confirmed.

**Bromides. Bromo-chloride of Silver. (Embolite.)**—Breithaupt examined the physical, and Plattner the chemical characters of bromochloride of silver from Colorado Mine, at Copiapo, in Chili.(2) It crystallises in octahedrons of the Regular system, with truncated edges, and presents traces of cleavage in the direction of  $\infty O \infty$ . It is completely ductile. It possesses adamantine lustre, is of a sulphur-yellow to siskin-green colour; but becomes externally olive- or asparagus-green. Its hardness is about = 2, and sp. gr. = 5.806. Its analysis gave :

Ag.	Br.	Cl.	Total.
66.862	20.088	13.050	100.00

Plattner establishes from this the formula  $2 \text{AgBr} + 3 \text{AgCl}$ . Breithaupt thinks that this mineral is a distinct species, and calls it embolite.

**Organoids. Mellite.**—Kenngott(3) determined in the mellite from Artern the inclination of  $\infty P \infty$  :  $P = 120^\circ 40'$  to  $120^\circ 55'$ , and the terminal edge of  $P = 118^\circ 11'$ , and the lateral edge of  $P = 93^\circ 2'$ . He thinks the latter angle the most correct.

**Hachetine.**—J. Rittler(4) found hachetine in balls of sphaeroiderite, from Rossitz, in Moravia. According to Haidinger's description, it is very similar to ozockerite, but softer. Its hardness = 1, its sp. gr. according to Patera's determination = 0.892, and its fusing-point is  $71^\circ$ . It dissolves easily in turpentine, in ether only with difficulty, and not at all in alcohol. We may expect an analysis from Redtenbacher.

**Dopplerite.**—Haidinger designated by the name of dopplerite, a mass occurring in large quantity in a deep peat-bog, not far from

- (1) Ann. Ch. Pharm. LXIX, 361; Rammelsb. Handw., 4. Suppl., 11 (in abstr.)
- (2) Pogg. Ann. LXXVII, 134; Rammelsb. Handw., 4. Suppl., 55 (in abstr.)
- (3) Kenngott's Min. Untersuchungen, 1849, 1. Heft, 17.
- (4) Wien. Acad. Ber. 1849, May, 312.

Aussee, in Styria, there called "Moder-substanz." According to Doppler's(1) and Haidinger's(2) description, this mass is in its native state gelatinous, with fatty vitreous lustre, brownish-black colour and dark wood-brown streak. Thin laminæ are translucent and reddish-brown; and present under the microscope delicate organic fibres. Its sp. gr., according to Foetterle, =1·089. Exposed to the air, this substance becomes very elastic, like caoutchouc.—According to Schrötter,(3) who analysed it, it is of perfectly vitreous lustre, after being dried at 100°, whereby it loses 78·5 per cent water, and much resembles the black pitch produced from coal-tar. Solution of potassa extracts nothing from the dried substance, but it dissolves 14·6 per cent out of the fresh substance (calculated on the dried mass, this=68 per cent) which is separated again by hydrochloric acid, and becomes again exactly like the original mass after drying. On boiling it with a solution of potassa, ammonia is evolved from the fresh substance. A combustion with oxygen gave (after subtracting the ash and 1·03 per cent of nitrogen calculated for 100 parts) 51·63 per cent carbon, 5·34 hydrogen, and 43·03 oxygen (from which the empyric formula  $C_8H_5O_5$  is calculated, which demands 51·61 carbon, 5·37 hydrogen, and 43·01 oxygen). Schrötter rightly regards this substance as a mass of peat more than ordinarily homogeneous, which in its formation from cellulose gave off hydrogen and oxygen in the form of water. (If we assume the formula of cellulose= $C_8H_7O_7$ , then 2 HO have disappeared.)

Regarding a fat-like substance from lignite (cerinine) see p. 498.

(1) Wien. Acad. Ber. 1849, November and December, 239.

(2) Ibid. 287.

(3) Ibid. 285.



# CHEMICAL GEOLOGY.

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Generalities.  
Magnetic  
properties  
of rocks.

**Generalities. Magnetic Properties of Rocks.**—Concerning Delesse's(1) investigations into the magnetic properties of rocks, see p. 115. Delesse has farther carried out the fusion-experiments with the various kinds of rock which we have mentioned in our previous Annual Report, II, 456, and has examined(2) the glasses thus produced as to their magnetic properties(3).

**Volcanic and Metallic Products and Formation of Veins.**—Elie de Beaumont(4) has communicated an ingenious treatise on volcanic and metallic emanations and the formation of veins, as they took place in the different geological epochs, and has added some views on the development of inorganic nature, by which he endeavours to delineate the progression of phenomena during the formation of the solid crust of the earth. A glance at the accompanying table will explain the principles on which he proceeds. The present volcanos on the one hand produce lava, and on the other hand carry up evaporised substances, which appear on the surface in the suffiones, solfataras and mineral springs. In the old fundamental volcanic rocks this diversity of action is still manifest; but the nearer we approach to granite and the granitic rocks, the less do the two sorts of eruptive action, the lava kind, and the sulphur kind, appear separately. But here, chemical and physical actions of another character manifest themselves. Together with heat, water plays, in this case, a most important part. The quantity of silica considerably increases, and with it the number of the elements ejected from the interior of the earth to the surface. Of the elements which exist in granite, only a small number are found as constituents in recent rock formations. Thus, by the formation of granite, matters were solidified, according to De Beaumont, which in later times would have exercised a destructive influence on organic nature. Bodies of inferior energy alone remained

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(1) Loc. cit. page 115; Jahrb. Miner. 1849, 285.

(2) Bull. Géol. [2] IV, 1380.

(3) Ann. Min. [4] XVI, 367; Compt. Rend. XXX, 84; Instit. 1850, 33.

(4) Bull. Géol. [2] IV, 1249.

# DISTRIBUTION OF THE ELEMENTS IN NATURE.

[To face page 554.]

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
	Elements most frequently occurring in the earth's crust.	Organic bodies.	Mineral springs.	Volcanic emanations.	New volcanic rocks.	Old volcanic rocks.	Fundamental rocks.	Elements occurring in the uncombined state.	Meteorites.	Granites.	Tin veins.	Ordinary veins.
Potassium	*	*	*	*	*	*	*	—	*	*	*	*
Sodium	*	*	*	*	*	*	*	—	*	*	*	*
Lithium	—	—	*	—	—	—	—	—	—	*	*	—
Barium	—	—	*	—	—	—	—	—	—	*	*	*
Strontium	—	—	*	—	—	—	—	—	—	—	*	*
Calcium	*	*	*	*	*	*	—	—	*	*	*	*
Magnesium	*	*	*	*	*	*	—	—	*	*	*	*
Yttrium	—	—	—	—	—	—	—	—	*	*	*	*
Beryllium	—	—	—	—	—	—	—	—	—	*	*	*
Aluminium	*	*	*	*	*	*	*	—	*	*	*	*
Zirconium	—	—	—	—	—	—	—	—	*	*	*	*
Thorium	—	—	—	—	—	—	—	—	—	*	*	—
Cerium	—	—	—	—	—	—	—	—	—	*	*	—
Lanthanum	—	—	—	—	—	—	—	—	—	*	*	—
Didymium	—	—	—	—	—	—	—	—	—	*	*	—
Uranium	—	—	—	—	—	—	—	—	—	*	*	—
Manganese	*	*	*	*	*	*	*	—	*	*	*	*
Iron	*	*	*	*	*	*	*	—	*	*	*	*
Nickel	—	—	—	—	—	—	—	—	*	—	*	*
Cobalt	—	—	—	*	—	—	*	—	*	—	*	*
Zinc	—	—	—	—	—	—	*	—	—	*	*	*
Cadmium	—	—	—	—	—	—	—	—	—	*	*	*
Tin	—	—	—	—	—	—	—	—	—	*	*	*
Lead	—	—	—	*	—	—	*	—	—	*	*	*
Bismuth	—	—	—	—	—	—	*	—	—	*	*	*
Copper	—	—	—	—	—	—	*	—	*	*	*	*
Mercury	—	—	—	—	—	—	*	—	—	*	*	*
Silver	—	—	—	—	—	—	*	—	—	*	*	*
Palladium	—	—	—	—	—	—	*	—	—	*	*	*
Rhodium	—	—	—	—	—	—	*	—	—	*	*	*
Ruthenium	—	—	—	—	—	—	*	—	—	*	*	*
Iridium	—	—	—	—	—	—	*	—	—	*	*	*
Platinum	—	—	—	—	—	—	*	—	—	*	*	*
Osmium	—	—	—	—	—	—	*	—	—	*	*	*
Gold	—	—	—	—	—	—	*	—	—	*	*	*
Hydrogen	*	*	*	*	*	*	*	—	*	*	*	*
Silicium	*	*	*	*	*	*	*	—	*	*	*	*
Carbon	*	*	*	*	*	*	*	—	*	*	*	*
Boron	—	—	*	*	—	—	—	—	*	*	*	*
Titanium	—	—	—	—	*	*	*	—	—	*	*	*
Tantalum	—	—	—	—	—	—	—	—	—	*	*	*
Niobium	—	—	—	—	—	—	—	—	—	*	*	*
Pelopium	—	—	—	—	—	—	—	—	—	*	*	*
Tungsten	—	—	—	—	—	—	—	—	—	*	*	*
Molybdenum	—	—	—	—	—	—	—	—	—	*	*	*
Vanadium	—	—	—	—	—	—	—	—	—	*	*	*
Chromium	—	—	—	—	—	—	*	—	*	*	*	*
Tellurium	—	—	—	—	—	—	—	—	—	*	*	*
Antimony	—	—	—	—	—	—	—	—	—	*	*	*
Arsenic	—	—	—	—	—	—	*	—	—	*	*	*
Phosphorus	*	*	*	*	*	*	*	—	—	*	*	*
Nitrogen	*	*	*	*	*	*	*	—	*	*	*	*
Selenium	—	—	—	*	—	—	—	—	*	*	*	*
Sulphur	*	*	*	*	*	*	*	—	*	*	*	*
Oxygen	*	*	*	*	*	*	*	—	*	*	*	*
Iodine	—	—	*	—	—	—	—	—	—	—	—	*
Bromine	—	—	*	—	—	—	—	—	—	—	—	*
Chlorine	*	*	*	*	*	*	*	—	*	*	*	*
Fluorine	*	*	*	*	*	*	*	—	*	*	*	*
	16	16	24	19	14	15	30	20	21	42	48	43

(1) On the presence of silver in various kinds of fucus, of land-plants, and in the animal organism, see page 425.

(2) On the presence of tin, zinc, antimony and lead, in mineral waters, see Annual Report for 1847 and 1848, II, 268.

(3) L. Gmelin found strontia in the basalt of Stetten, in the Högau (see Rammelsb. Handw., I, 79); Rammelsberg in that of Engelhaus, near Carlsbad (see Rammelsb. Handw., 4 Suppl., 17).

(4) Mentioned by Shepard as occurring in the iron of Cocke County, Tennessee (see Sill. Am. J. [2] IV, 14).

(5) Was found in the iron of Braunau, by Fischer and Duflos (Annual Report for 1847 and 1848, II, 510). According to Silliman, jun., arsenic occurs also in the meteoric iron of Texas and Lockport (Annual Report for 1847 and 1848, II, 518).

(6) Rammelsberg found tin in the meteoric iron of Seeläsgen (Annual Report for 1847 and 1848, II, 511).

(7) Is found, according to Rammelsberg, in the meteorite of Juvenas (Annual Report for 1847 and 1848, II, 506).



behind, but the equilibrium between the organic world, and the matter necessary for it, was established and is kept up; this is shown in the table by comparing the elements of organic bodies, with those which are most widely spread in nature, and are to be found in the volcanic products of modern time.

Volcanic  
and  
metallic  
products  
and  
formation  
of veins.

In the oldest crystalline rocks, which formed the first covering of the earth, the abundance of elements is the greatest; a similar abundance prevails in their immediate emanations, in those products which De Beaumont describes as the vein-formations of granite, and which he designates by the general name of tin-ore-veins. Next to these come more recent veins, which are formed by the eruption of masses less rich in quartz, whose point of egress lies deeper in the interior of the earth. These are the ordinary veins to which especially lead-glance-veins belong. In the third rank appear mineral waters, which constitute a continuation of the various phenomena of emanation. The ejected products of volcanos form the fourth class; they are somewhat poorer in elements than the mineral waters, but have some resemblance to them. The oldest period of the formation of granite is marked by a fixation of silicium and potassium, apparently on account of their greater capability of oxidation. Other bodies remained unoxidised in the depth, such as palladium, rhodium, platinum, osmium, iridium, &c., and were only occasionally brought to the surface.

The ordinary ore-veins, which, on account of the predominating mineral, may be called lead-glance-veins, Beaumont considers entirely analogous to the ejected products of modern volcanoes, and the deposition from mineral springs; he believes that they are formed by a sublimation, during which the matter was carried over with the steam. They differ from the modern phenomena of this kind only in so far as they are subordinate to more ancient eruptive rocks, while mineral waters are principally found in countries of volcanic activity, or at least where the crust of the earth has been subject to many disturbances. The volatilisation of metallic bodies in lead-veins, and those analogous to these, took place by means of the so-called mineralising substances, such as sulphur, selenium, chlorine, iodine, bromine, arsenic, phosphorus, antimony and tellurium. The presence of oxidised metals on the surface of many veins, Beaumont ascribes to the water, charged with oxygen, reaching the surface from the atmosphere, while the *un*-oxidised substances, which form the real veins, proceeded from the principal springs or from vapours, which came directly from rocks not yet cooled. According to this mode of origination, we can understand also the way in which metals are usually associated in veins, since such as have similar chemical properties occur together; for example, nickel and cobalt, iron and manganese, antimony and arsenic.

On the contrary, the tin-veins, or those analogous to these, are

Volcanic  
and  
metallic  
products  
and  
formation  
of veins.

distinguished by the presence of anhydrous silicates, by quartz, in veins, by the absence of mineralising bodies, and farther, as the table shows, by the abundance of simple bodies, and by their constant relation to the granites; their production stands in the closest connection with the origin of granite itself. To this last Beaumont attributes an eruptive origin at a high temperature, and is of opinion that the silica, which played a part in its formation, must have been of an aqueous and gelatinous character. In the formation of the minerals, which are included by granite and the tin-ore-veins, he believes that several elements acted in a similar manner as chlorine and sulphur in the recent lavas, but the agents which carried off with them tungsten, molybdenum, tantalum, &c., were of far greater energy; and he shares the opinion of Daubrée, that fluorine, phosphorus and boron have been these agents. Hence the tin-ore-veins appear to have been the first fumerôles of granitic masses, while the more recent ore-veins are the fumeroles of the eruptive rocks, to which they are subordinâtes.

**Formation of Minerals and Ores in Veins.**—Daubrée(1), both by direct experiments(2), as well as by the consideration of geological results, has come to the conclusion that tinstone, titanite acid (brookite, anatase, rutile), specular iron, and partly also quartz, owe their origin to the decomposition of fluorides and chlorides by steam. Hence there must have been in earlier periods fumeroles containing hydrofluoric acid, which existed in the middle of a crater of elevation as, for example, in Oisans. From these inquiries Daubrée draws the conclusion that this mode of production, by which the fixed minerals became volatile, must have played an important part in the metamorphoses of rocks, and that the hydrofluoric acid in granite is derived from the same source.

**Association (Paragenesis) of Minerals.**—It cannot be denied, that certain laws prevail over the association of minerals, and that in nature the existence of certain minerals depends on the existence of others. Now, though we are able only in a few cases to form a correct idea of the original connection of these phenomena, yet surely an accurate statement, which establishes the facts, is itself of great interest; and A. Breithaupt, who distinguishes the whole of this doctrine by the name *paragenesis of minerals*, has communicated his ideas on this subject in a special work(3) which, on account of its copiousness, admits of no abstract. We only remark, that the subject has also its practical value, as the search after useful minerals will be

(1) Compt. Rend. XXIX, 227; Instit. 1849, 292; Arch. Ph. Nat. XII, 147; Ann. Min. [4] XVI, 129; Jahrb. Miner. 1849, 712; Sil. Am. J. [2] IX, 122; Dufrénoy's Report to the Academy, Compt. Rend. XXX, 383; Froriep's Berichte aus d. Natur- u. Heilkunde, 1850, Nr. 39.

(2) See this Report, p. 8.

(3) Die Paragenesis der Mineralien, Freiberg, 1849.

facilitated, if the circumstances are well ascertained, which are associated with a successful result. In reference to the history of formation, an accurate investigation of the age of various bodies, as it may be inferred from their succession, is evidently of the highest importance; and in this respect the work of Breithaupt will serve as a foundation for similar inquiries. We only add the order of the formations of veins as enumerated by Breithaupt. These are groups of minerals, occurring together in veins, and following one another in definite succession, which is recognised by the structure of the vein. The enumeration begins with the oldest, and concludes with the most recent group. They are named after the minerals which predominate in them, and Breithaupt adduces for each the cases of paragenesis with which he has become acquainted.

1. Pyroxene-garnet-pyrites-blende-formation; 2. Titanium-formation; 3. Noble quartz-formation; 4. Pyritic lead-zinc formation; 5. Ancient cobalt-formation; 6. Tin-tungsten-formation; 7. Tellurium-gold-formation; 8. Clinoëdric(1) lead-zinc-formation; 9. Späthic iron-formation; 10. Copper-formation; 11. Antimony-formation; 12. Manganese-iron-formation; 13. Fluorine-baryta-formation; 14. Recent cobalt-nickel-formation; 15. Barytic lead-zinc-formation; 16. Barytic copper-formation; 17. "*Edle geschicke-formation*,"(2) or silver-formation; 18. Barytic mercury-formation; 19. Zeolitic formation; 20. Phosphatic formation.

Boué(3) has written upon the geographical and geological distribution of minerals, ores and rocks, with especial reference to their origination.

**Decomposition of Rocks by Water.**—W. B. Rogers and R. E. Rogers(4) have laid before the British Association their inquiries into the action of pure water and water charged with carbonic acid upon minerals and various kinds of rocks, the substance of which we have communicated in the preceding Annual Report(5). They detail, moreover, experiments upon the relative solubility of carbonate of lime, and carbonate of magnesia in water containing carbonic acid. These contradict the supposed greater solubility of carbonate of lime, and the theory founded upon it, of dolomite being formed by the abstraction of the former and the relative increase of the carbonate of magnesia. By the exhaustion of pulverised dolomite with water charged with carbonic acid, it was found that carbonate of magnesia exists in a greater proportion to the carbonate of lime in

(1) Breithaupt designates by the term, clinoëdrite, a mineralogical genus of the order of glances, embracing crystallised weissgültigerz, schwarzgültigerz, schwarzerz, fahl-ore, tennantite, copper-blende and tin-copper-glance.

(2) Silver with misspickel, quartz, &c.

(3) Mém. de la Soc. Géol. de France, III, 1. partie; Arch. Ph. Nat. XII, 326 (short notice).

(4) Instit. 1849, 399.

(5) Annual Report for 1847 and 1848, II, 465.

Decomposition of rocks by water.

the solution than corresponds to the pulverised rock. In the stalactites of the cavern of Weyer in Virginia, certainly only traces of magnesia are found; but in this case the carbonate of magnesia may have been conveyed to greater depths, by the atmospheric waters, a supposition which appears to be confirmed by the great abundance of it in the springs of the neighbourhood.

**Dependence of Springs for their Ingredients on the Soil.**—We(1) have already mentioned Grange's comparative researches into the waters of various geological formations, and the dependence of their saline constituents on the elevation at which they occur. Grange has pursued these investigations(2), and considered especially the geological situations in which goitre and cretinism appear in Switzerland and Savoy. He has been confirmed in his opinion that the cause of this disease lies in the water that is drank, and indeed in its containing magnesia. He found that goitre occurs in the Alps as an endemic below and upon magnesian formations, and particularly on the Meeresmolasse, the Nagelfluh, whose springs contain much magnesia, on lias and hornblende rocks; that it is principally found on the lines of separation which divide the country into stripes parallel to the direction of the great chain, and where uniform strata of gypsum and dolomite are met with; that it disappears above these formations, but has its greatest intensity between and upon them. On the upper and lower chalk, on the upper jura-formation, where magnesian rocks do not occur, goitre is quite unknown.

**Evolution of Gas.**—S. S. Howard(3) reports a remarkable spontaneous evolution of gas, at the village of Charlemont in Staffordshire, to the discovery of which a labourer was led, by the absence of all vegetation on the spot. When he fixed pipes in the ground he obtained a constant stream of gas which burnt with a bright, bluish, pale flame, giving heat and light; and he found the same in his cottage also, which was at the distance of 150 yards from this spot, so that he and his neighbour could apply 9 gas-pipes, without perceiving a diminution of gas, even after burning it for many weeks. The spot is at the distance of more than a mile from a coal-mine, but in the neighbourhood occur several fissures in the ground, and it is probable that the gas finds its way through these out of the great coal deposits of the neighbourhood. According to the analysis of Howard, the gas consists of carburetted hydrogen; he found in 1000 volumes 996 volumes of carburetted hydrogen gas,  $C_2H_4$ , 3 volumes carbonic acid, and 1 vol. aqueous vapour and nitrogen. The sp. gr. of the gas is 0.56126. Its combination is somewhat different from that of the natural marsh gas and the gas in old mines, by its containing less carbonic acid and nitrogen.

(1) See Annual Report for 1847 and 1848, II, 466.

(2) Compt. Rend. XXIX, 695; Arch. Ph. Nat. XIII, 251.

(3) Instit. 1849, 406; Chem. Gaz. 1849, 409.

**Origin of Carbonic Acid.**—G. Bischof(1) found that carbonic acid is gradually separated from carbonate of lime, carbonate of protoxide of iron and carbonate of magnesia by silicic acid, both in its soluble and insoluble modification (pulverised quartz), with the co-operation of boiling water. Carbonate of magnesia actually loses its carbonic acid under the influence of boiling water alone. The exhalations of carbonic acid from the interior of the earth (Laacher See, Eifel), especially those from the suffiones of Tuscany, have, according to Bischof, such an origin. According to the law of the increase of temperature, at a depth of 8600 feet in the interior of the earth, the boiling temperature certainly prevails, and this depth is doubtless reached by the aluminous slate. If limestone strata and, quartzous rocks exist there, and if water obtains a passage through them, even at that small depth, carbonic acid must be set free.

**Carbonate of Lime in Sea-water.**—J. Davy's(2) observation that the quantity of carbonate of lime in sea-water increases in the neighbourhood of coasts, and almost disappears at a great distance from land, is of importance to Geology, as pointing out the development of lime-secreting organic beings in the neighbourhood of coasts.

**Formation of Sulphur, Gypsum, Anhydrite and Alunite.**—Coquand(3) has communicated very valuable contributions to the history of the formation of the sulphur, gypsum, anhydrite and alunite, in the solfataras, alum-pits and lagoons of Tuscany, which all, although in different degrees, are the latest manifestations of volcanic action which has affected the soil of Tuscany; and among which the appearance of plutonic rocks, and the formation of deposits of metallic ores, mark the period of the greatest intensity. This excellent treatise does not well admit of an abstract. It is worthy of remark that there is proved in it an intimate connection between the antimony-veins and the solfataras, the frequent occurrence, in the solfatara of Pereta, of quartz, assuming the pseudomorphous forms of antimony-glance, in the macigno, *i. e.* in a rock, that, according to most geologists, belongs to the uppermost strata of the chalk-formation. The occurrence, in Pereta, of alunite free from iron, produced from the shales underlying the limestone, is accounted for by the formation of soluble iron-compounds, which are continually washed away, while insoluble alumite remains behind, which loses this insolubility—arising from an excess of alumina—only by being submitted to a process of roasting.

Ehrenberg(4) has observed, for the first time, infusoria (45 species) in a specimen of gypsum from Asia Minor. From the

(1) Verhändl. d. rhein. naturf. Gesellschaft zu Bonn, 1849, 23. Febr.; Jahrb. Miner. 1849, 725.

(2) See 425, where some observations of White are mentioned.

(3) Bull. Géol. [2] VI, 91; Jahrb. Miner. 1849, 484.

(4) Berl. Acad. Ber. 1849, 193; Arch. Ph. Nat. XII, 252; Instit. 1849, 413.



Formation  
of sulphur,  
gypsum,  
anhydrite  
and  
alumite.

determination of these infusoria, it results that gypsum is a fresh-water formation, and probably belongs to the brown-coal-formation. It contains 38 polygastrica, 6 phytolitharia, and 1 entomostraca.

T. S. Hunt(1) pointed out the connection that exists between the gypsum-deposits and the springs containing free sulphuric acid of the Onondaga salt-groups of the upper silurian system in Canada. The gypsum-deposits of that country always rise in hills, or dome-formed masses of from 1 to 400 feet in diameter. These rest on undisturbed limestone-strata, whilst the upper strata are thrown up, and in part rest on the sides of the gypsum-mounds, and have also in part disappeared. In one case, a thin cylinder of gypsum passes through several limestone-strata, and ends in a cone of the usual form, which being surrounded by the tertiary clay of the neighbourhood is therefore quite of recent origin. It has also been observed in western New York that such gypsum-cones have been frequently formed since the first colonisation of the country, and have destroyed the foundation of houses by gradually rising. Hunt ascribes the origin of the gypsum to the action of the sulphuric acid on the limestone, but has as yet expressed no opinion as to where he looks for the origin of the sulphuric acid itself. The amount of free sulphuric acid and of bases contained in the springs is very variable, and Hunt looks for the cause of this variability in the protection afforded by the formation of the gypsum to the tube of the spring. This great variability was observed in the Tuscarora-spring; but while on the one hand the condition of the neighbouring vegetation affords proof that the process is of recent origin, on the other it appears already exhausted in this case. The carbonic acid, which according to this explanation should make its appearance, had not been found, only a small quantity of carburetted hydrogen was observed.

**Proportion of Water in Feldspathic Rocks.** — Deville and Du-rocher(2) contradict the assumption of water being originally contained in the feldspar of feldspathic rocks. Delesse(3) not only asserts this, but attributes the presence of water in basalt, &c.; not, as has hitherto been the case, to the intimate admixture of an hydrated mineral (zeolite), but directly to the water, which enters into the constitution of the felspars and the other minerals. He was led to this opinion, principally by the examination of melaphyre, which also contains water, and in the mass of which zeolites have not as yet been found. He states that the minerals present in the drusic cavities of these rocks are quite different from those which are found in the mass of the rock itself. If zeolites

(1) Sill. Am. J. [2] VII, 175; the analysis of the Tuscarora-spring, see p. 433.

(2) Bull. Géol. [2] VI, 387.

(3) Bull. Géol. [2] VI, 393; Froriep's Ber. aus d. Natur- u. Heilk. 1850, Nr. 84; Arch. Ph. Nat. XII, 323 (in abstr.)

formed a constituent of melaphyre, the silica would assume the gelatinous form on the mineral being treated with acids, which is not the case. It is true that gelatinous silica is separated from the basalt by hydrochloric acid; but this, he states, proceeds from the olivine; labradorite and augite also are more or less attacked, according to Delesse. The perfect condition of the cleavage-planes of certain crystals of felspar and augite, in which water is found, is said to exclude the presence of a zeolite, and the water which exists in chemical combination in the former is considered as the true source of the water which is contained in feldspathic rocks.

Proportion  
of water  
in feld-  
spathic  
rocks.

**Products of Burning Coal-seams.**—C. Blondeau(1) has investigated the efflorescences of the burning mountain, near Cransac, in the department of Aveyron (a burning coal-bed, containing a great deal of iron pyrites), and has founded upon his observations a plan for an immediate method of producing sulphuric acid.(2) He found in 100 parts: sulphate of alumina-potassa 24·25, sulphate of alumina 53·31, sulphate of magnesia 3·47, sulphate of manganese 1·35, sulphate of iron 10·29, free sulphuric acid 7·33. Moreover, crystals of sulphur and sal-ammoniac are found as products of sublimation.

**Petrifactions in Talc-slate.**—Coquand(3) describes the occurrence of a *Lima gigantea* in a talcose slate in the Gulf of Spezzia. The shell was changed into a very crystalline, finely-grained marble. Talc, as a petrifying agent of ferns, had been already observed at Moutiers, in Savoy.(4)

**Unstratified Rocks. Formation of Granite.**—Scheerer(5) endeavours to refute the objections made by Durocher to his theory of the formation of granite. We must refer to the treatise itself.

**Pegmatite.**—Delesse(6) has investigated the pegmatite of the Vosges. This forms irregularly-shaped veins, which without any fixed order penetrate through the granitic rocks of the Vosges; it is always found with tourmaline, and plays the same part as the schörl in Cornwall. It consists of white quartz, of flesh-coloured felspar, silvery mica, and dark green tourmaline, and belongs to the variety of granite which is richest in silica, the amount of it rising to nearly 78 per cent. For his investigation of orthoclase and mica we refer to pp. 526 and 530.

**Felsite-porphry.**—Hochmuth(7) has published investigations of the porphyry of Löbejün, near Halle.

(1) Compt. Rend. XXIX, 405.

(2) See page 448.

(3) Bull. Géol. [2] VI, 525.

(4) Naumann's Handbuch der Geognosie, I, 830.

(5) Bull. Géol. [2] VI, 644; see Annual Report for 1847 and 1848, II, 479.

(6) Ann. Min. [4] XVI, 97; J. Pr. Chem. XLVII, 460; Arch. Ph. Nat. XI, 318 (in abstr.); Compt. Rend. XXIX, 24; Ann. Ch. Phys. [3] XXVIII, 124.

(7) From Der Bergwerksfreund, 1847, XI, 441 in Rammelsb. Handw., 4. Suppl., 181; see Naumann's Geognosie, I, 609.

Felsite-  
porphyry.

A. Porphyry of Schiedsberg, dirty yellow, thick and compact, contains orthoclase and albite (more probably than oligoclase), small portions of greenish-black augite, and rarely quartz. Sp. gr. 2·6317. —B. Porphyry from the Martinsschacht. The fundamental mass is dark reddish-brown, occasionally brownish-yellow and green and blue. The felspar-crystals are smaller and less distinct. Some parts have the appearance of augite. Sp. gr. of the ordinary variety (a.) = 2·6486, of a light green variety (b.) in which the separation of felspar quite disappears = 2·683. —C. The so-called greenstone, the extreme end of the porphyry, filling up a basin-shaped cavity in the coal-formation. It is dark leek-green, dense, very hard. By means of a lens felspar can be recognised, and, though rarely, quartz. By the variety (b.) of the former, it is in direct apposition with the porphyry. Sp. gr. = 2·766.

	SiO <sub>3</sub> .	Al <sub>2</sub> O <sub>3</sub> .	FeO.	MgO.	CaO.	NaO.	KO.	Loss.	Total.
A.	66·19	13·43	6·46	2·36	0·46	2·56	5·08	2·57	99·11
B a.	64·25	12·64	8·63	1·14	2·50	2·60	4·33	1·15	97·24
B b.	61·50	13·78	11·89	1·58	1·20	7·39 *		2·66	100
C.	59·87	11·21	14·88	5·87		5·09		2·54	99·46

\* Loss.

Hochmuth, from this, calculates the several constituents, as follows:

	A.	B a.	C.
Potassa-felspar	30·61	25·87	23·33
Soda-felspar	21·71	21·93	10·27
Augite	20·50	27·38	46·97
Quartz	19·90	16·94	11·46
Alumina	3·79	3·97	5·01
Total		96·09	97·07

The more recent porphyry of Wettin (sp. gr. 2·483) contains, according to Hochmuth, 75·82 per cent SiO<sub>3</sub>, 8·73 Al<sub>2</sub>O<sub>3</sub>, 3·65 Fe<sub>2</sub>O<sub>3</sub>, 1·45 MgO, and is therefore different from the former.

Delessé(1) describes a porphyry of Schirmeck, in the Vosges, which perforates in veins a lime of the devonian formation. It consists of a felspathic paste, of oligoclase, (see this Report p. 527) and of mica. The paste contains carbonate of lime, and its amount of silica characterises it as compact oligoclase.

Delessé(2) communicates, moreover, his investigations on quartz-porphyry (felspar-porphyry, red porphyry) which contain new matter in addition to some that was known before. The felspar of the triclinometric system, which is found along with that of the mono-

(1) Ann. Min. [4] XVI, 362.

(2) Ann. Min. [4] XVI, 233; Bull. Géol. [2] VI, 629; Jahrb. Miner. 1850, 186.

clinometric system, is, according to Delesse, andesine(1), sometimes also oligoclase, but not albite, which he has not yet found in any granitic rock. The fundamental mass of the red porphyry Delesse considers as the residue left after the crystallisation, consisting of silica in combination with alumina, sesquioxide of iron, lime, magnesia and the alkalies, in a word, with all the bases, which are found in minerals that occur in the rock. It is a feldspathic paste, the composition of which does not agree with any definite felspar. Delesse supposes the same of all porphyry rocks, such as melaphyres, basalts and lavas, of which he does not believe that the compact paste surrounding the crystals consists of any definite mineral.

The composition of the whole mass of quartz-porphyry Delesse found to be as follows (A. Porphyry of Montreuillon; B. Porphyry of Saulieu, Côté d'Or):

	SiO <sub>3</sub> .	Al <sub>2</sub> O <sub>3</sub> .	Fe <sub>2</sub> O <sub>3</sub> .	Mn <sub>2</sub> O <sub>3</sub> .	CaO.	KO	NaO	MgO	Loss.	Total.
A	71.7	15.0	2.9	—	0.4	8.8			1.2	100.0
B	77.5	12.9	2.5	trace	0.4	5.9			0.8	100.0

The well characterised quartz-porphyry, in which crystals or grains of quartz are found, contains an amount of silica, which always equals, or even exceeds, that of a granite rich in silica. It varies from 70 to 80 per cent. Like granite, it contains less than one per cent of lime but more sesquioxide of iron and less of alkalies.

**Diorite.**—The diorite of Pont-Jean, in the Vosges, consists, according to Delesse(2), essentially of an actinolitic hornblende and a labradorite (about 47 per cent hornblende and 53 per cent felspar). Concerning these two minerals, see p. 522 and 527. Moreover, sometimes it is found with more, sometimes with less of a fundamental mass, which probably contains likewise the before-mentioned constituents, together with chlorite or green-earth, and a compound carbonate of protoxide of iron, magnesia and lime. In consequence of a radiated disposition of the labradorite round a centre, this diorite frequently assumes a globular structure.—In small quantity, titanite iron, iron pyrites, epidote, quartz and calcspar are moreover present.

The diorite described by Delesse(3) from Foymont, in the Vosges, contains quartz, principally in veins, andesine-felspar (see p. 527), hornblende (see p. 522), mica and sphene. The felspar is sometimes accumulated in a radiated form round a centre, and thus produces a true spheroidal diorite.

(1) See Annual Report for 1847 and 1848, II, 410; Arch. Ph. Nat. XIII, 235.

(2) Ann. Min. [4] XVI, 339; Compt. Rend. XXX, 176.

(3) Ann. Min. [4] XVI, 356.

**Aphanite.**

**Aphanite.**—Delesse(1) has investigated the aphanite of Saint-Bresson (Haute Saône). This is of a dark green colour, approaching to greenish-black; in it are observed greenish-black, microscopic and somewhat fibrous laminæ, which are like hornblende, some iron pyrites and very fine minute veins of pistacio-green epidote; but on the whole it is homogeneous, and appears formed of a granular felspathic paste, which decomposes with a white crust, and in which very fine striæ intimate a triclinometric felspar. Its sp. gr. is 2.968. Its composition is:

SiO <sub>2</sub> .	Al <sub>2</sub> O <sub>3</sub> .	Fe <sub>2</sub> O <sub>3</sub> .	MnO.	CaO.	MgO.	NaO.	KO.	Loss.	Total.
46.83	30.33		trace	9.55	6.86	3.57	0.81	1.99	100.00

Where this aphanite penetrates through the granite, the latter changes its grain, and turns into a kind of feldstone-rock, gradually passing into aphanite. This rock contained silica 63.80 per cent, alumina and some protoxide of iron 18.67, lime 2.25, magnesia, alkalis, water and loss 15.28. On the other hand, aphanite on the plane of contact contained 46.47 per cent of silica, and only 7.57 per cent of lime. The granite, therefore, has by its contact with aphanite experienced a diminution of silica, which may be explained by an accession of bases from the intruded aphanite, and an increase of lime, protoxide of iron and magnesia; the aphanite itself became poorer in these last, but richer in silica, and formed with the bases of the granite a rock having a feldstone character.

**Gabbro, or Euphotide.**—Delesse(2) has instituted some investigations on euphotide (gabbro), especially on the euphotide of Mont Genève. Concerning the felspar (saussurite) composing this rock, which contains water, and the diallage (smaragdite), see the Report on Mineralogy, p. 525—521. The felspar belongs to the triclinometric system, but has not always the same composition, since it approaches sometimes labradorite, sometimes vogsite, sometimes anorthite, which is also the case in the porphyries of the transition-rock of the Vosges.—Moreover, this euphotide contains magnetic iron, in which frequently titanium or chromium are present, pyrites, talc and serpentine, the last often in such abundance that it becomes doubtful whether to call this rock serpentine or euphotide; besides these, it also contains carbonates, and generally carbonate of protoxide of iron with lime and magnesia, which occurs as well in the crystals of felspar and diallage as in the whole mass of rock. The felspar is the predominating ingredient, and the properties of the whole rock therefore do not differ much from those of felspar.

(1) Ann. Min. [4] XVI, 347; Arch. Ph. Nat. XIII, 232.

(2) Ann. Min. [4] XVI, 238; Bull. Géol. [2] VI, 547; J. pr. Chem. L, 52; Arch. Ph. Nat. XII, 325 (in abstr.)

Delesse found the composition of the whole mass to be: silica 45.00, alumina and sesquioxide of iron 26.83, lime 8.49, magnesia, soda and potassa 13.90, water and carbonic acid 5.78.

Gabbro,  
or  
Euphotide

The euphotide from Odern, in the Vosges(1), which Delesse has also investigated, has, as its principal constituents, a triclinometric felspar (which in one and the same rock, approaches now to labradorite, now to anorthite, and now to other varieties of felspar)(2), olive-green diallage, which is an uralite(3), magnetic iron, iron pyrites, talc, serpentine, and a carbonate of an apparently complicated character, consisting of protoxide of iron, lime, and magnesia. At the point of contact with the transition-slate of Odern, laminæ of talc also appear in this, and an imperceptible transition takes place of the euphotide, now into a kind of talcose slate, and now into a serpentine-slate. In veins this euphotide contains, moreover, amorphous quartz, calcspar, rarely also epidote, asbestos, and small crystals of albite and axinite.

**Eulysite.**—A. Erdmann(4) mentions a new kind of rock, which, like the eclogite of Germany, forms in Sweden strata in gneiss. It contains in a granular mixture, augite (apparently diallage), garnet, and nearly 50 per cent of a mineral related to olivine, likewise containing a basic silicate, in which the greatest part of the magnesia is replaced by protoxide of iron and manganesc. On treating this rock with hydrochloric acid, the latter mineral is decomposed with separation from gelatinous silica: the garnet- and augite-grains are separated. Erdmann calls this kind of rock on this account eulysite(4).

**Melaphyre.**—Delesse(5) has analysed the amygdaloid porphyry (melaphyre), of Oberstein. The porous fundamental mass, which is dark-brown, almost inclining to red, contains a great quantity of felspar crystals, spathic iron, and some titaniferous iron (*fer oxydulé titané*), together with small agate nodules. There is also found in it, though sparingly, pinchbeck-brown mica. The felspar is a labradorite(6). Delesse never saw hornblende in the fundamental mass, although the colour of the porphyry is ascribed to an admixture of this substance; on the other hand, he observed in it microscopic nodules of a mineral similar to chlorite(7). The analysis of the fused fundamental mass gave as the mean composition, silica 51.13,

(1) Arch. Min. [4] XVI, 325; Compt. Rend. XXX, 148; Pharm. Centr. XXI, 254; J. Pr. Chem. L, 52.

(2) See page 527.

(3) See page 521.

(4) Jahrb. Miner. 1849, 837.

(5) Ann. Min. [4] XVI, 509.

(6) The analysis of this felspar, see page 527.

(7) Delesse designates this mineral as *Chlorite ferrugineux*, and ranges it between chlorite proper and repidolite. Naumann has proposed the name *delessite* (see his Lehrs. d. Geognosie I, 605).

Mela-  
phyre.

alumina and sesquioxide of iron 29.73, lime 4.73, magnesia, alkalis, and loss 10.73, carbonic acid and water 3.68. The melaphyre of Oberstein differs from its felspar only in this, that it contains rather less alumina and alkali, and rather more sesquioxide of iron and magnesia.

The above-mentioned mineral, resembling chlorite, agrees entirely with a similar substance found in the porphyry of Planitz, in Saxony; with regard to its composition, see the Report on Mineralogy, p. 542.

Delesse(1) has investigated a porphyry (melaphyre) out of the transition-rocks of Chagey (Haute Saône). Its colour is dark-green, and it contains greenish felspar crystals. Delesse considers the water contained in it as the result of polymeric isomorphism(2), and the felspar itself as andesine. The colour of the porphyry proceeds from a dark-green crystalline substance like augite, which is accompanied by very little magnetic iron. The accidental minerals are the same as in the melaphyre of Belfahy(3). Sp. gr. of the porphyry = 2.759. Loss on ignition from 1.73 to 6.17 per cent. The composition of the fundamental mass was:

SiO <sub>2</sub> .	A <sub>2</sub> O <sub>3</sub> and Fe <sub>2</sub> O <sub>3</sub> .	MnO.	CaO.	MgO.	NaO and KO.	H <sub>2</sub> O.	Total.
61.71	25.44	trace	4.79	2.98	2.74	2.34	100.00

This porphyry in some places turns imperceptibly into slate, and Delesse considers it a metamorphic rock.

**Basalt.**—Grandjean(4) endeavours to prove that the basalt of the Westerwald, like green stone, porphyry, and shales of the transition-rocks in Nassau, have nothing to do with plutonic actions, without however denying to all basalts a plutonic origin. Grandjean believes, that out of the muddy deposits of bituminous clay of the brown-coal-formation, anhydrous silicates, like hornblende and augite, are formed in the moist way; enclosed in a solid basaltic paste these silicates may become hydrated again under the influence of the atmospheric agents, and gradually disintegrating, be converted into a trass-like stone. We will hereafter again return to Grandjean's views, when he shall have published the farther elaborations of this subject, which he promises.

Rammelsberg(5) examined the basalt of Engelhaus, near Carlsbad, among the constituents of which augite and olivine are discernible. Concerning olivine, see the Mineralogical part of our Report, p. 523. The basalt is separated by hydrochloric acid

(1) Bull. Géol. [2] VI, 383.

(2) See Annual Report for 1847 and 1848, II, 379.

(3) Ibid., II, 487.

(4) Thomä's Jahrb. f. Naturk. IV, 143; Jahrb. Miner. 1849, 604.

(5) Rammelsberg's Handw., 4. Suppl., 16.

into a decomposable part A, which amounts to between 44.98 and 43.1 per cent, and into an undecomposable part B, the quantity of which is between 55.02 and 56.9 per cent. The loss on ignition amounted to between 3.04 and 3.24 per cent.

	SiO <sub>3</sub>	PO <sub>5</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	FeO	MnO	MgO	CaO	SrO	NaO	KO	HO	Total
A.	33.74	1.01	14.41	7.94	15.97	0.26	9.55	5.28	0.10	3.42	2.77	6.90	101.35
B.	55.16	—	7.42	—	10.12	—	12.68	13.60	—	0.66	0.36	—	100.00

If we subtract from A  $7.94 \text{ Fe}_2\text{O}_3 + 3.57 \text{ FeO} = 11.51 \text{ FeO}$ ,  $\text{Fe}_2\text{O}_3$ , and calculate the quantity of olivine that would result from the amount of magnesia, we find 11.51 per cent of magnetic iron, and 20.85 per cent of olivine, and as a remainder:

SiO <sub>3</sub>	PO <sub>5</sub>	Al <sub>2</sub> O <sub>3</sub>	FeO	MnO	CaO	SrO	NaO	KO	HO	Total
25.54	1.01	14.41	9.30	0.26	5.28	0.10	3.42	2.77	6.90	68.99

Starting with the amount of alumina, calculation gives for B 24.99 per cent of labradorite, and 75.01 of augite.

Bergemann(1) has examined the basalt of Obercassel, near Bonn, (sp. gr. 2.937). It contains no zeolites, and only very little olivine, but crystallised calcespar. It contains 55.04 per cent of matter decomposable by hydrochloric acid (A), and 44.96 which is not decomposed (B).

	FeO, CO <sub>2</sub>	CaO, CO <sub>2</sub>	MgO, CO <sub>2</sub>	SiO <sub>3</sub>	Al <sub>2</sub> O <sub>3</sub>	NaO	Fe <sub>2</sub> O <sub>3</sub>	HO	Total
A.	14.60	7.90	1.15	14.25	3.75	0.80	7.50	6.09	55.04
B.	1.23	7.20	2.32	23.18	9.41	1.26	—	—	44.60

Part B would be by calculation 28.07 labradorite with 16.53 augite.

Bergemann calculates Part A as carbonates 22.65, zeolitic portion 24.89, magnetic iron 7.50. Rammelsberg(2) points out, however, that the determination of the amount of carbonic acid is wanting, and that it is inadmissible to calculate the three bases as carbonates, which stands, moreover, in opposition to the results of former experience regarding basalt. So large an amount of water, too, has never been observed in a basalt, especially in one poor in zeolites. The supposed zeolitic substance in which the ratios of oxygen of  $\text{SiO}_3$ :  $\text{Al}_2\text{O}_3$ :  $\text{NaO}$ :  $\text{HO}$  are 36:9:1:27, he states, is not likely to be a zeolite, and probably still contains a certain quantity of lime.

Baumann(3) has investigated the basalt of Bollenreuth, in the Fichtelgebirge, which is rich in olivine. Concerning olivine, see p. 523. The basalt is split up by hydrochloric acid into 47.78 per cent of decomposable matter (A), and 52.22 per cent of matter which is not decomposed (B). According to a special experiment, Part A contains 16.67 per cent of  $\text{Fe}_2\text{O}_3$ , which requires 7.49 FeO in order

(1) Karsten's Archiv. XXI, 3; Rammelsberg's Handw., 4. Suppl., 18.

(2) Rammelsberg's Handw., 4. Suppl., 18.

(3) Ibid., 13.



**Basalt.** to form 24.16 of magnetic iron  $\text{FeO}$ ,  $\text{Fe}_2\text{O}_3$ . Keeping this in view, the analysis of A gave the following result :

$\text{SiO}_2$	$\text{Al}_2\text{O}_3$	$\text{Fe}_2\text{O}_3$	$\text{FeO}$	$\text{MgO}$	$\text{CaO}$	$\text{NaO}$	$\text{KO}$	$\text{HO}$	Total.
39.80	6.99	16.67	19.24	7.11	3.52	3.34	1.77	1.56	100.00

If we deduct from this 24.16 magnetic iron, there remains :

39.80	6.99	—	11.75	7.11	3.52	3.34	1.77	1.56	75.84
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If the whole of the magnesia belongs to the olivine, calculation gives an amount of this mineral of 17.37 per cent, the remainder consisting of

32.04	6.99	—	9.25	—	3.52	3.34	1.77	1.56	58.47
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probably contains a zeolite, but cannot by calculation be separated into any known minerals, and that mainly on account of the high amount of iron it contains. Its composition approximates to  $4\text{RO} + \text{Al}_2\text{O}_3 + 5\text{SiO}_3 + \text{HO}$ .

The analyses of B gave :

$\text{SiO}_2$	$\text{Al}_2\text{O}_3$	$\text{FeO}$	$\text{MgO}$	$\text{CaO}$	$\text{NaO}$ , with some $\text{KO}$	Total.
51.69	12.16	8.95	7.57	17.52	2.11	100.00

If the whole of the alumina belongs to labradorite, calculation gives 40.87 per cent of labradorite, and 59.66 per cent of augite.—The basalt therefore consists of

A. Magnetic iron	11.54	B. Labradorite	21.34
Olivine	8.30	Augite	30.88
Undeterminable Hydrosilicate	27.94		

Concerning basalt, see also p. 574.

**Dolerite.**—Bergemann(1) has published a treatise upon the chemical and mineralogical composition of several volcanic rocks on the left bank of the Rhine, which were formerly considered as trap, augite-rock, granular hornblende and augite porphyry, but which he believes to be true dolerite(2). He treated these rocks with hydrochloric acid, by which they were decomposed into a soluble and insoluble part. The insoluble part was treated with hydrofluoric acid and carbonate of soda. The amounts of proto- and sesquioxide of iron were found by direct experiment.

*Rock from the summit of the Schaumberg, near Tholei*, which Steininger(3) had considered to be a mixture of titaniferous iron and albite. It resembles a coarse-grained dolerite, in which it is difficult to discover the constituents; it is of a brownish or greenish-black

(1) Karsten's Archiv. XXI, 3; Rammelsb. Handw., 4. Suppl., 49.

(2) Naumann enumerates this rock as melaphyre, (see his Lehrb. der Geognosie), I, 599.

(3) Geognostische Beschreibung des Landes zwischen der unteren Saar und dem Rhein, Trier, 1840, 99; Nachträge, 1841, 21.

colour, and consists of an accumulation of crystallised particles, which, when examined by a lens appear some laminar and some acicular, and of which a few are distinguished by a pure black colour, and by their brighter lustre. Other particles are translucent and yellowish, and also possess a crystallised structure. Greenish-yellow points, like olivine, also occur in it, which, however, are identical with the fundamental mass of the rock. The hardness is that of quartz, the sp. gr. 2.7504, the loss on ignition 3.448 per cent. It contains between 24.57 and 29.25 per cent of matter decomposable by hydrochloric acid (A), and between 75.43 and 70.75 of matter which is not acted on by hydrochloric acid (B).

	SiO <sub>3</sub>	Al <sub>2</sub> O <sub>3</sub>	NaO.	KO.	HO.	FeO, CO <sub>2</sub>	CaO, CO <sub>2</sub>	Fe <sub>2</sub> O <sub>4</sub> *	CaO.	MgO.	FeO.	Total.
A.	9.13	1.09	0.19	—	0.75	7.84	1.30	4.28	—	—	—	24.58
B.	40.16	21.25	3.16	0.02	—	—	—	—	9.79	0.64	0.33	75.35

\* Containing titanium.

The rock contains in its soluble part A about 11.172 of a doubtful silicate, 4.375 magnetic iron, 9.040 carbonate of protoxide of iron and carbonate of lime. In its insoluble part 70.806 of labradorite, and 4.607 of a green mineral, which Bergemann on the result of calculation considers to be augite(1). This last forms, when looked at through a lens, oblique, four-sided prisms, which are striated lengthways, and are translucent with a dark brownish-green colour. Before the blow-pipe they are fusible only at the extreme edges, and there only with difficulty, differing in this respect greatly from augite. The distribution of the augite in the fundamental mass is very variable. Some parts appear quite white, others thickly dotted.

Rammelsberg doubts whether the part soluble in hydrochloric acid actually contains a silicate with 82 per cent of silica, which is opposed by the results of former experience.

*Rock of the western declivity of the Schaumburg*, already in a state of disintegration. By continued ignition it loses 6.7 per cent(2), and becomes of a reddish-brown colour. It contains 29.325 per cent of matter decomposable by hydrochloric acid (A) and 70.675 of matter which is not decomposed (B).

	SiO <sub>3</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub> , HO.	CaO, CO <sub>2</sub>	NaO.	HO.	Fe <sub>2</sub> O <sub>4</sub> *	CaO.	MgO.	FeO.	Total.
A.	9.33	1.07	11.51	1.32	0.01	1.68	4.40	—	—	—	29.32
B.	38.89	20.17	—	—	2.79†	—	—	7.63	0.32	0.87	70.67

\* With traces of titanium.

† With traces of potassa.

(1) Delesse, on the other hand, considers the second constituent of these rocks as hornblende (Naumann's Handb. d. Geognosie, I, 561).

(2) As the water of hydrated sesquioxide of iron amounts to 1.66 per cent, the quantity of water would be 3.34. If we add to this 0.58 CO<sub>2</sub> from the carbonate of lime, the loss on ignition nevertheless would not exceed 3.92 per cent, whence Rammelsberg expresses some doubts respecting the alleged loss of 6.7 per cent (see Rammelsb. Handw., 4. Suppl., 49).

Dolerite.

Calculation yields: magnetic iron 4.45; hydrated sesquioxide of iron 11.51; carbonate of lime 1.32; silicate 12.04; labradorite 61.26; augite 9.41.

*Rock from Schaumberg*, on the road from Tholei to Thelei, occurs in spherical accretions(1). Interior nucleus non-disintegrated. Intimate mixture of white and black parts; sp. gr. 2.837.

SiO <sub>2</sub> .	Fe <sub>2</sub> O <sub>3</sub> .*	Al <sub>2</sub> O <sub>3</sub> .	CaO.	NaO.†	HO.
42.72	18.64	23.76	9.88	3.61	2.02

\* Partly as FeO, as magnetic iron.

† With a trace of potassa.

The insoluble constituent is labradorite. The nucleus of the spheres consist of about  $\frac{3}{4}$  of labradorite and  $\frac{1}{4}$  magnetic iron.

*Rock from Martinstein near Kirn*. It agrees externally almost entirely with that from Schaumberg. Sp. gr. 2.748. 29.98 per cent (A) are decomposed by hydrochloric acid, 70.15 per cent (B) are insoluble.

	SiO <sub>2</sub> .	Al <sub>2</sub> O <sub>3</sub> .	NaO.	HO.	FeO, CO <sub>2</sub> .	CaO, CO <sub>2</sub> .	Fe <sub>2</sub> O <sub>4</sub> .*	CaO.	MgO.	FeO.	KO.
A.	13.73	3.25	0.25	0.75	3.75	2.00	6.26	—	—	—	—
B.	37.03	19.22	2.80	—	—	—	—	10.26	0.68	0.04	0.12

\* Containing titanium.

It has the following composition: carbonate of protoxide of iron and lime 5.75; silicate(2) 17.97; magnetic iron, containing titanium, 6.25; augite 5.51; labradorite 64.58.

*Rock from Weisselberg* is like pitchstone, very dense, of a coal-black colour, of a conchoidal fracture, and of a fatty lustre. There are many white points in the rock which, when highly magnified, look like small white crystals, and which Steininger considered to be albite. Its hardness is greater than that of quartz. Its sp. gr. = 2.685. Composition:

SiO <sub>2</sub> .	Al <sub>2</sub> O <sub>3</sub> .	Fe <sub>2</sub> O <sub>3</sub> .	FeO.	CaO.	MnO.	MgO.	NaO.	KO.	Loss on ignition.*
60.60	18.59	1.18	1.30	2.14	0.44	0.30	8.64	1.00	6.45

\* On ignition, a strongly empyreumatic odour is evolved; the vapour is ammoniacal.

With hydrochloric acid, this rock separates into 14.27 per cent (A) of decomposable, and 86.36 per cent (B) of undecomposable matter.

	SiO <sub>2</sub> .	Al <sub>2</sub> O <sub>3</sub> .	Fe <sub>2</sub> O <sub>3</sub> .	FeO.	CaO.	NaO.	MgO.	MnO.	KO.	Loss on ignition.
A.	2.34	1.80	1.18	0.95	0.94	0.62	—	—	—	6.44
B.	58.26	16.79	—	0.35	1.20	8.02	0.44	0.30	1.00	—

Bergemann calculates the following composition, according to which the rock cannot be classified with pitchstone, but resembles

(1). See the description of Steininger (see p. 568), 104 and Nachträge, 24.

(2) The hydrated silicate of alumina (A) would contain 76 per cent of acid, an amount which is doubted by Rammelsberg. According to the latter, it contains moreover lime and protoxide of iron, and includes a certain quantity of labradorite, which is also attacked by acids (see Rammelsb. Handw., 4. Suppl., 51).

those of Schaumberg and Martinstein. Albite 81·00; hornblende 9·20; magnetic iron 3·00; organic matter and water 6·44; total 99·64(1).

Dolerite.

So-called *melaphyre of Pitschberg*. Externally this rock presents the greatest resemblance to basalt. It forms a black, very fine-grained, solid and compact mass, in which, even by the aid of a lens, only few crystalline particles are discernible. The degree of hardness is that of basalt, the sp. gr. 2·9047. Some greenish-yellow dots consist of olivine. This rock loses by ignition 2·414 per cent. It consists of 39·37 per cent (A) of decomposable, and 60·63 per cent (B) undecomposable matter.

	SiO <sub>3</sub> .	Fe <sub>2</sub> O <sub>3</sub> .	Al <sub>2</sub> O <sub>3</sub> .	CaO.	MgO.	NaO.	FeO.	Total.
A.	16·67	16·17	2·75	1·75	1·35	0·65	—	39·34
B.	32·38	—	8·11	10·54	4·12	1·01*	4·55	60·71

\* With some potassa.

Bergemann calculates that the composition of this melaphyre is: olivine 3·89 per cent; silicate of iron 35·06; labradorite 22·15; augite 38·66; total 99·76.

The known typic *dolerite of the Meissner*, in the Electorate of Hesse, which resembles the Schaumberg rock, has been also examined by Bergemann. Its sp. gr. is 2·8105; it acts strongly on the magnetic needle. It loses by ignition 1·89 per cent. It contains 42·5 per cent (A) of matter decomposable by hydrochloric acid, and 57·5 per cent (B) of matter which is not acted upon.

	SiO <sub>3</sub> .	Al <sub>2</sub> O <sub>3</sub> .	FeO.   CO <sub>2</sub> .	NaO.	CaO.   CO <sub>2</sub> .	Fe <sub>2</sub> O <sub>3</sub> .†	MgO.‡	Total.
A	17·37	4·22	8·57	0·62	2·72	8·93	—	42·43
B	30·38	14·65	1·12   —	2·01*	7·77   —	—	1·25	57·18

\* With some potassa

† Containing titanium.

‡ With some protoxide of manganese.

Accordingly (1·89 per cent of water, which is mostly hygroscopic, being left out of consideration), it consists of carbonate of lime and of protoxide of iron 11·29 per cent; silicate of soda and of alumina 22·21; magnetic iron containing titanium 8·97; augite 9·27; labradorite 47·91; total 99·65(2).

*Doleritic rock from Siegburg*. It is coarse-grained, and many shining particles are to be seen on freshly fractured surfaces. Sp. gr. 2·7601: hygroscopic water 1·70 per cent. It contains 34·09 per cent of matter decomposable in hydrochloric acid (A), and 65·91 (B) of matter which is not acted upon.

(1) Rammelsberg considers that this interpretation is also inadmissible.

(2) Rammelsberg declares the assumption that (A) contains the whole of the protoxide of iron and of lime, in the form of carbonates to be improbable (Handw., 4. Suppl. 53).

Dolerite.

	FeO.	CO <sub>2</sub> .	CaO.	CO <sub>2</sub> .	SiO <sub>2</sub> .	Al <sub>2</sub> O <sub>3</sub> .	Fe <sub>2</sub> O <sub>4</sub> .	MgO.	NaO, with a little KO.	Total.
A.	21.01	—	6.74	—	1.09	1.64	3.61	—	—	34.09
B.	3.96	—	11.01	—	33.92	10.46	—	4.78	1.36	65.5

Consequently, the rock consists of carbonate of lime and of protoxide of iron 27.75; silicate of alumina 2.73; magnetic iron 3.61; labradorite 30.06; augite 35.43; total 99.58.

*Rock of Niedermendig*, the well-known Rhenish millstone. It contains hygroscopic water 0.347 per cent; it divides into 57.2 per cent portion soluble in hydrochloric acid (A), and 42.8 insoluble in it (B).

	SiO <sub>2</sub> .	Al <sub>2</sub> O <sub>3</sub> .	CaO.	KO.	Fe <sub>2</sub> O <sub>3</sub> .	PO <sub>5</sub> .	Cl.	NaO.	FeO.	MgO.	MnO.	Total.
A.	21.10	9.21	3.16	0.86	15.60	10.8	trace	4.54	—	—	—	56.27
B.	25.16	7.21	0.63	1.10	—	—	—	2.43	4.01	2.23	—	42.77

Bergemann believes that this lava consists of 34.5 per cent of a silicate easily decomposable by acids of the formula RO, SiO<sub>2</sub> + Al<sub>2</sub>O<sub>3</sub>, SiO<sub>2</sub>, and 42 per cent of a vitreous felspar, with which are mixed 13 per cent magnetic iron, about 4 per cent apatite, and about 2.5 per cent of free sesquioxide of iron.

**Wacke.**—Schafhäütl(1) has examined a green porphyry wacke from Sillberg, near Berchtesgaden. It has an earthy, granular appearance, of a dark leek-green, to light-green and gray colour. It becomes porphyritic, owing to the presence of a laminar dark pistachio-green mineral frequently crystallised in six-sided tables, like chlorite or carbonate of lime, and is penetrated by nest-like parts of crystallised laminar iron-glance, which is often surrounded by brown-spar. A specimen of dark-leek-green fracture (I), and one of light-green fracture (II), exhibited, on analysis, the following composition:

	SiO <sub>2</sub> .	Al <sub>2</sub> O <sub>3</sub> .	Fe <sub>2</sub> O <sub>3</sub> .	MgO.	UO.	KO.	HIO.	Cl.	Total.
I.	40.750	16.150	18.750	11.423	1.350	5.500	6.300	trace	100.203
II.	50.400	14.125	14.100	10.000	0.738	5.320	5.284	trace	99.967

Schafhäütl concludes from the deportment of the rock with cold and boiling hydrochloric acid and boiling potassa, by which silicic acid is extracted, that it consists of a variety of chlorite, perhaps ripidolite, and a potassa-felspar. This wacke passes into a sandstone(2), and this last greatly resembles a granitic formation, since it consists of quartz, tourmaline, and dichroite, and interspersed red copper-ore partly changed into malachite; all these minerals, never occur in quantities sufficiently large to consider them as secondary deposits. Schafhäütl accordingly believes, that they are

(1) Anzeigen der Münchener Academie, 1849, 417; Jahrb. Miner. 1850, 64.

(2) Formerly described by Schafhäütl (see Jahrb. Miner. 1846, 663).

formed in the locality itself by chemical processes resembling those which have given rise to the formation of granite.

Trass.

**Trass.**—Schafhäütl(1) has communicated a chemical analysis of the trass from the Riese, near Nördlingen, in Bavaria, which there occurs with granitic formations. This trass differs from that of the Brohl-valley, from that of Puzzuoli, and in general from volcanic tuffa; and it greatly resembles a pearlstone-formation. Schafhäütl considers it an original formation, which in a watery semi-fluid state has oozed out of clefts in the surface of the earth; the rock has a dusty pulverulent appearance in those places where disintegration has begun. By aid of a lens it is seen, that this trass, notwithstanding the variety of its exterior appearance, is always composed of three constituents. One is a yellowish, amorphous, frequently granular mass of waxlike clay; the second is like the first, but more translucent and white, and swells up with loud decrepitation before the blowpipe, running out into points, and at last fusing with difficulty to a hard blistery glass. Both are interwoven by more or less dull lavender-blue, but often also pitch-black masses of remarkably fatty lustre. The rock is full of cavities, which are either empty, or else contain a granule of the yellow substance, of a fibrous feathery appearance, like obsidian-pumice.—The bluish substance, which often appears in masses as large as a hen's egg, gives the tuffa a slag-like appearance. It melts before the blowpipe, loses its colour and becomes a bubbly glass. The lavender-blue constituent is, in greater masses, pitch-black, and gives sparks with steel. This portion seems to represent the rock in its original state. It differs by its containing a smaller proportion of silica from obsidian, pitchstone and pearlstone. It is decomposed by acids into a part soluble in them 14·96 per cent (A), and 85·04 insoluble matter (B); the analyses of the entire rock gave the composition (C).

	SiO <sub>2</sub> .	Al <sub>2</sub> O <sub>3</sub> .	Fe <sub>2</sub> O <sub>3</sub> .	CaO.	MgO.	KO.	NaO.	HO.	Total.
A	47·54	14·58	12·37	2·00	7·08	5·34		11·09	100·00
B	68·23	10·15	3·82	2·41	7·98	0·34		7·07	100·00
C	65·15	10·85	5·10	2·35	7·85	5·25	1·57	1·95	100·07

Out of the yellow porous mass, caustic potassa extracts 5·65 per cent silicic acid. The residue has the composition (A) of feldstone.—The trass as a whole gave the composition (B).—The yellowish portion of the same, so far as it could be separated from the interspersed black constituent, yielded the composition (C); hydrochloric acid decomposed 24·88 per cent (D), and left 75·12 per cent (E) unacted on.

(1) Jahrb. Miner. 1849, 641 (see the description of this trass by Cotta, in Jahrb. Miner. 1834, 307, and by Voith, *ibid*, 1835, 169.)

Trass.

	SiO <sub>2</sub> .	Al <sub>2</sub> O <sub>3</sub> .	Fe <sub>2</sub> O <sub>3</sub> .	CaO.	MgO.	KO.	NaO.	HO.	Total.
A	65·96	16·04	4·34	2·09	0·19	7·13	2·87	1·38	100·00
B	67·55	15·05	4·08	1·97	0·18	6·70	2·70	1·30	99·53
C	64·91	10·88	5·26	2·21	7·71	5·31	1·59	2·00	99·87
D	44·21	13·18	11·75	1·92	7·07		5·62	16·25	100·00
E	69·29	9·73	2·96	2·10	7·64		7·06	1·22	100·00

Schafhäütl considers this trass as an aqueous formation as a mixture of opal and felspar, and thinks that it came up as a hot mud charged with water, and that it is not connected with any formation of tuffa. Of a similar origin, according to Schafhäütl, is a so-called "true basalt," from that neighbourhood (from Wengenbergl, on the Wörnitz), which has exactly the same composition as the trass. This basalt contains 31·12 per cent of matter (A) which is soluble in hydrochloric acid and 68·12 per cent of insoluble matter (B). They consist of:

	SiO <sub>2</sub> .	Al <sub>2</sub> O <sub>3</sub> .	Fe <sub>2</sub> O <sub>3</sub> .	CaO.	MgO.	KO.	NaO.	HO.	Total.
A.	44·17	13·09	11·57	2·18	7·18	5·52		16·30	100·00
B.	71·59	9·36	2·17	2·12		7·53		7·23	100·00

Schafhäütl goes farther, and considers that felspathic and granitic rocks also originated in this way, as is already known from his previous researches upon this subject.

**Stratified Rocks. Dolomite.**—A. Favre and Marignac(1) have made some investigations which throw much light on the history of the formation of the dolomites in the Tyrol, but also, like all dolomite-theories hitherto formed, confirm the view, that limestones containing magnesia and true dolomites have not always originated in the same way. Favre does not consider the dolomites of the Tyrol as metamorphic rocks, but believes that they have been deposited as such, and recognises their connection with the eruptive augite rocks, a connection which Leopold v. Buch in his celebrated treatise was the first to point out. He thinks that when these dolomites were deposited with augitic tuffas at the bottom of the sea, the conditions supposed by Haidinger(2) to be essential for the origin of dolomite all existed—namely, the presence of sulphate of magnesia and carbonate of lime, a temperature of about 200° (at a considerable depth, and with volcanic eruptions), and a pressure of 15 atmospheres (in a sea of from 150 to 200 metres deep).—Sulphate of magnesia must have been formed in great quantities in consequence of the sulphurous acid accompanying the volcanic eruptions, acting upon the magnesia of the tuffas. This must have been attended by the formation of chloride of magnesium, if simultaneously emanations of hydrochloric acid took place, which

(1) Arch. Ph. Nat. X, 177 (compl.); Instit. 1849, 83 (in abstr.); Bull. Géol. [2] VI. 318; Jahrb. Miner. 1849, 742; Wien. Acad. Ber. 1849, März, 168.

(2) See Annual Report for 1847 and 1848, II, 499.

seem to have happened.—Marignac found, that by heating carbonate of lime and a solution of chloride of magnesium in a sealed glass tube to  $200^{\circ}$ , during six hours, a product with 48 per cent of  $\text{CaO}$ ,  $\text{CO}_2$  and 52 per cent of  $\text{MgO}$ ,  $\text{CO}_2$  was precipitated, *i. e.* with more magnesia than the true dolomite requires, and that chloride of calcium remained in solution; whence it follows, that chloride of magnesium, like sulphate of magnesia, is capable of forming dolomite with carbonate of lime. When Marignac heated the glass tubes only during two hours, a dolomite was formed with only a small amount of magnesia, whence it is evident that a certain time is necessary for the formation; this shows, moreover, the reason why we find in nature limestones containing magnesia, true dolomites, and such as contain magnesia in excess.

The cavernous structure, which is met with throughout the whole extent of the Tyrolese dolomite, but is wanting in others, Favre considers, as the result of a metamorphism which took place shortly after the deposit of limestone, whereas the compact dolomite was precipitated from the first as a double salt. That animals could live in a sea so rich in salt as this, is proved by an observation of Verneuil(1), for he saw species of cardium and other shell-fish living in a basin of the Crim, in which the salt crystallises in summer. By the decomposition of sulphate of magnesia and of carbonate of lime, gypsum also is formed, which under the influence of heat assumes the form of anhydrite. According to Charpentier, the gypsum of the Alps is derived from anhydrite, which itself frequently occurs in them. In the highly crystalline dolomites of Gotthardt, Favre recognises, with Fournet(2), the result of the fusion of a limestone rich in magnesia, which may have affected it in the same way, as it has the crystalline limestone of the corresponding stratification.

Forchhammer(3) has given a view of the formation of dolomite, which is founded upon experiments. The following analyses first evinced the small quantities of carbonate of magnesia, which is found in the usual limestones, and especially in such as have had their origin in organic beings.

	$\text{CaO}$ , $\text{CO}_2$ .	$\text{MgO}$ , $\text{CO}_2$ .	$\text{CaO}$ , $\text{SO}_3$ .	$\text{CaO}$ , $\text{PO}_5$ .	$\text{SiO}_2$ .	$\text{Fe}_2\text{O}_3$ .	$\text{FeO}$ .	$\text{MnO}$ .	Inso- luble residue.	Organic mat- ter, water and loss.	Total.
A.	98.986	0.371	0.073	0.045	0.436	0.089		—	—	—	100.000
B.	98.246	0.924	—	0.155	—	—	0.276		0.399	—	100.000
C.	91.52	1.01	—	—	—	—	0.58		2.24	4.65	100.000

A. Chalk from Alindelille, in the neighbourhood of Ringstedt.—B. limestone from Faxö.—C. Phrygæan limestone from Clermont.

(1) Mém. de la Société Géolog. de France, III, 9.

(2) Annales de la Société d'Agriculture de Lyon, IV, 12.

(3) From Oversigt over det Kongelige Danske Videnskab. Selskabs Forhandlingar, 1849, 5, 6 in J. Pr. Chem. XLIX, 52; Instit. 1849, 407 (partly); Arch. Ph. Nat. XIII, 241; Chem. Gaz. 1849, 411.



**Dolomite.** In the same manner most of the limestones behave, which are formed of shells and corals, and Forchhammer has for this purpose investigated various corals and shells(1). The percentage of the carbonate of magnesia in these was as follows :

<i>Astræa cellu-losa.</i>	<i>Myriazon trun-catum.</i>	<i>Helenopora abrota-noides.</i>	<i>Eschara foliacea.</i>	<i>Fron-di-pora re-ticulata.</i>	<i>Coral-lium no-bile.</i>	<i>Isis hip-puris.</i>	<i>Terebra-tula psit-tacea.</i>	<i>Modiolus papuana.</i>
0·542	0·445	0·352	0·146	0·596	2·132	6·362	0·457	0·705

<i>Pinna nigra.</i>	<i>Trito-nium anti-quum.</i>	<i>Cerithium teles-copium.</i>	<i>Nautilus pompi-lius.</i>	<i>Ossa sepiæ.</i>	<i>Serpula sp., Mediter-ranean.</i>	<i>Serpula triquetra, North Sea.</i>	<i>Serpula filograna, North Sea.</i>
1·000	0·486	0·189	0·118	0·401	7·644	4·455	1·349

According to the mode of formation of most limestones Forchhammer assumes, that a limestone which contains above 2 per cent of carbonate of magnesia is a dolomitic limestone, and that serpulæ, corallium and isis, and probably several other species of animals, are capable of forming this rock. A limestone, which contains above 13 per cent of carbonate of magnesia, he calls dolomite, and shows by treatment with acetic acid, that the so-called compact dolomite, is not a mixture of  $\text{CaO}$ ,  $\text{CO}_2$  and  $\text{MgO}$ ,  $\text{CO}_2$ , but an actual double salt mixed with  $\text{CaO}$ ,  $\text{CO}_2$ (2).

In the white chalk of Denmark there is found, near Faxö, a peculiar limestone, which consists of caryophyllites and oculines, and contains nearly 1 per cent of carbonate of magnesia(3), which is as much as corresponds with these lime-secreting animals. This is covered by a yellow sandy lime(4), in which yellow spheres of dolomite(5) are found, which contain from 16 to 17 per cent of carbonate of magnesia. This last is, according to Forchhammer, the product of springs, whose ancient channels of influx are perceptible in the form of large cylindrical perpendicular hollows, and which, wherever they penetrated through the coralline limestone, have covered the

(1) See Dana's investigation of coralline chalk, in Annual Report for 1847 and 1848, II, 501.

(2) The portion described consisted of 97·13 per cent  $\text{CaO}$ ,  $\text{CO}_2$ , and 2·87  $\text{MgO}$ ,  $\text{CO}_2$ ; the portion insoluble of 58·38  $\text{CaO}$ ,  $\text{CO}_2$  and 41·42  $\text{MgO}$ ,  $\text{CO}_2$ , which nearly agrees with equal equivalents.

(3) See its analysis, p. 575.

(4) Its composition was carbonate of lime and loss 95·75; carbonate of magnesia 0·64; silicic acid containing iron 2·74; sesquioxide of iron 0·87.

(5) Two specimens of this dolomite gave the composition :

	$\text{CaO}$ , $\text{CO}_2$ .	$\text{MgO}$ , $\text{CO}_2$ .	$\text{SiO}_2$ .	$\text{Fe}_2\text{O}_3(\text{FeO}?)$ .	HO and loss.	Total.
A*.	80·67	16·48	0·81	2·04	—	100·00
B.	79·89	17·03	0·65	1·29	1·14	100·00

\* In this specimen the lime was not determined, whence the water and loss are not known.

sides of the crevices and the fossils with a more or less thick crust, likewise containing only a trifling quantity of magnesia, but, irrespectively of the lime, a good deal of sesquioxide of iron. Forchhammer is, on this account, of opinion that the springs deposited carbonate of magnesia chiefly in those places where the magnesian salts of sea-water decomposed their carbonate of lime. His experiments led to the result, that in such cases carbonate of lime is always precipitated with carbonate of magnesia. If water be employed, which contains only carbonate of lime, the precipitate, formed by mixing it with boiling sea-water, contains 12·23 per cent of carbonate of magnesia, (this is the reason, that Forchhammer places the limit for dolomitic limestone at 13 per cent of carbonate of magnesia) the rest is carbonate of lime. By increasing the temperature, the quantity of magnesia appears also to augment, and higher degrees of temperature may have existed during the formation of real dolomites, so rich in magnesia, as those which occur in nature. If the water contains carbonate of soda also, as well as of lime, a much larger quantity of carbonate of magnesia is precipitated (in an experiment as much as 27·93 per cent).

The water of some mineral springs, when boiled with sea-water, gave precipitates of the following composition :

	Selters.	Pymont.	Wildungen.
CaO, CO <sub>2</sub>	86·55	84·38	92·12
MgO, CO <sub>2</sub>	13·45	5·12	7·88
FeO, CO <sub>2</sub>	—	10·50	—

The Faxö limestone bears the character of a coral reef, and it appears as if its springs had also carried with them a surplus of lime for the marine animals, and perhaps caused the development of these animals by their warmth.

The cavities in the porous dolomite of Fullwell, in Sunderland, (the honeycombstone) are considered by Forchhammer as gas-bubbles of evolved carbonic acid; he believes, that this as well as the globular forms (*Quellkugeln*), confirm the account he has given of its formation. That gypsum is so often associated with dolomite is accounted for by carbonic acid being expelled in its formation by sulphuric acid, whereby a great quantity of chalk is dissolved, which in turn with the sea-water forms dolomitic limestone. A dolomite, which may be placed here, is that from Stigsdorf, in Holstein, which is black and bubbly, like lava, and contains rolled pebbles. Its composition is as follows :

CaO, CO <sub>2</sub> .	CaO, SO <sub>3</sub>	MgO, CO <sub>2</sub> .	SiO <sub>2</sub> .	Fe <sub>2</sub> O <sub>3</sub> , Al <sub>2</sub> O <sub>3</sub> .	Coal, water, loss.	Total.
80·55	0·95	7·49	5·82	2·83	2·36	100·00

Dolomite.

In a treatise on the geology of the Island of Bute, Bryce<sup>(1)</sup> communicates several analyses of limestones, and of so called dolomites from the neighbourhood of greenstone- and basalt-veins, which however, throw but little light on the phenomenon of dolomitisation. Macadam, in investigating these limestones, found, that at their contact-surfaces with trap they are very soft and saccharoidal, and have a very trifling amount of magnesia (2 to 3 per cent), whilst, when farther removed from it, they form a hard crystalline dolomite (with 34 per cent of magnesia). Both contain soluble silica, but a greater quantity of this substance is a mechanical admixture. A more detailed analysis of this limestone was undertaken under the direction of R. D. Thomson, which confirms in the main points the foregoing statement, and which we here communicate :

	SiO <sub>2</sub> and Al <sub>2</sub> O <sub>3</sub>	FeO	CaO, CO <sub>2</sub>	MgO, CO <sub>2</sub>	Water, carbonaceous substance and carbonic acid.
Saccharoidal limestone, from contact of the dike at Kilchattan*	6.91	1.68	90.65	1.00	—
	5.16	1.50	—	—	—
	5.70	1.28	91.08	1.17	—
Hard, crystalline marble, somewhat more distant from the dike†	1.94	0.52	96.48	1.23	—
	0.28	—	98.76	—	—
	0.28	0.56	96.58	2.24	—
Limestone, unchanged, from the middle of the quarry, far from the dike‡	9.70	1.12	67.42	17.31	4.45
	—	—	72.12	—	—
	9.08	1.12	67.00	18.06	4.74
Limestone, changed, touching the overlying trap of Ascog Mill	64.21	6.42	24.00	4.62	1.75
	64.46	6.60	21.20	2.85	4.89

\* Sp. gr. 2.710.

† Sp. gr. 2.570.

‡ Sp. gr. 2.679

**Limestone.**—Schramm<sup>(2)</sup> has undertaken an investigation of the limestones of Würtemberg for alkalies and phosphoric acid; from which, he shows that the first seldom occur as chlorides, but chiefly as carbonates. In the lower muschelkalk, the chlorine could still be quantitatively determined, in the upper muschelkalk only traces of chlorine were found, in the carboniferous formation none at all. In the keuper there were traces of chlorine, only determinable in the red keuper-marl. In the upper black jura chlorine was again to be found in determinable quantity; in the brown there were only traces of it. Sulphuric acid was never found; once only, when several

(1) Phil. Mag. [3] XXXV, 81; Sill. Am. J. [2] VIII, 420.

(2) From Würtemb. naturwiss. Jahresheften V, 58, in J. Pr. Chem. XLVII, 440 (in abstr.)

pounds of common chalk were boiled with water there were found some traces of sulphuric acid. Phosphoric acid was found with certainty only in the ripple-marked dolomite (wellendolomit). The following table gives the results in percentage composition:—

Lime-  
stone.

	KO, CO <sub>2</sub> .	NaO, CO <sub>2</sub> .	KCl.	NaCl.	PO <sub>5</sub> .
(1) Lowest ripple-marked dolomite from Wittensweiler, near Freudenstadt	0.3048	0.6208	0.0382	0.0627	0.1763
Upper ripple-marked dolomite from Aach	0.2531	0.5548	0.0216	0.0520	0.0637
Ripple-marked lime from Eggenhausen	0.2303	0.5200	0.0177	0.0419	—
Cellular lime from Aach, from the Salzgebirge	0.1860	0.4118	0.0165	0.0374	—
Middle muschelkalk from Rottwell	0.154	0.259	0.023	0.041	—
" " " Dornstetten.	0.1332	0.2392	0.0218	0.0406	—
Porous dolomite muschelkalk from Untertürkheim	0.2045	0.3364	0.0259	0.0387	—
Encrinitic limestone from Kirchberg, on the Jaxt	0.2300	0.2190	0.0264	0.0246	—
Thinly stratified limestone from Wilhelmglück	0.2280	0.1892	trace	—	—
Upper coarsely stratified muschelkalk from Untertürkheim	0.1641	0.2884	trace	—	—
Top muschelkalk, with bone-bed, from Crailsheim	0.1840	0.2423	trace	—	—
Upper porous dolomitic limestone, of the Letten coal-formation, from Ludwigsburg	0.2088	0.4172	—	—	—
Limestone resting upon coal near Kornwestheim	0.1458	0.3595	—	—	—
(2) Green aluminous marl from Spitzberg, near Tübingen.	0.1233	0.1794	trace	—	—
Blue marl from Spitzberg, near Tübingen	0.1680	0.2495	trace	—	—
Red keuper marl from Spitzberg, near Tübingen.	0.1453	0.2218	0.0092	0.0146	—
Leberkies, iron pyrites, from the Bopser, near Stuttgart	0.2589	0.4299	trace	—	—
Keuper dolomite from Stuttgart	0.1594	0.2457	trace	—	—
(3) Sandy limestone from Neuhausen, auf den Fildern	0.1856	0.1416	0.0301	0.0366	—
Nagelkalk from Stuttgart	0.1853	0.1886	0.0238	0.0250	—
Lower black jura, pylonotic strata, from Stollingen	0.1582	0.3502	0.0095	0.0277	—
Numismalis marl from Dusslingen, near Tübingen	0.0804	0.1247	trace	—	—
Posidonic slate from Boll	0.0616	0.0533	trace	—	—
Jurensis marl from Metzingen. Top lias marl	0.1763	0.2291	trace	—	—
(4) Lower brown jura from Metzingen	0.1991	0.2784	trace	—	—
Ferruginous oolite from Aalen	0.2039	0.2299	trace	—	—
(5) Lower white jura from Urach	0.1881	0.2209	—	—	—
Middle white jura from Urach	0.1875	0.2566	—	—	—
Upper white dolomitic jura from Urach	0.1116	0.1333	—	—	—
Upper reddish compact jura from Insberg	0.0762	0.0841	—	—	—
Upper yellow compact jura from St. Florian, near Metzingen	0.11204	0.00513	—	—	—
Coralline limestone from Nattheim	0.10397	0.03529	—	—	—
Upper white jura (krebsscheerenkalk) from Böhmekirch	0.1069	0.0347	—	—	—
(6) Chalk-like fresh-water limestone from Blaubereun	0.0672	0.0344	—	—	—
Fresh-water limestone from Okenhausen, near Heidenheim	0.06318	0.01510	—	—	—
(7) Calcareous limestone from Honau	0.1225	0.1736	—	—	—
" " Cannstadt	0.0361	0.2722	—	—	—

(1) Formation of muschelkalk.

(2) Formation of keuper.

(3) Black jura.

(4) Brown jura.

(5) White jura.

(6) Fresh-water-limestone without definite formation.

(7) Is continually forming.

Faist(1) repeated these experiments under the direction of

(1) From Würtemb. naturwiss. Jahresheften V, 72, in J. Pr. Chem. XLVII, 445 (in abstr.)

Lime-  
stone.

Fehling, and the results agree on the whole with those of Schramm. Potassa is always found associated with soda. The following is the percentage amount of alkaline carbonate in various rocks. Marly muschelkalk from Zoffenhausen 2·77 and 2·93(1); ripple-marked limestone from Freudenstadt 0·315. Red marl nodules from the Felgersburg, near Stuttgart 0·11; red marl from the Weinsteige, near Stuttgart 0·07; hard stone marl from the same quarry 0·07; hard marl frequently occurring with crystallised heavy spar about 0·096; blue marl from the same quarry 0·12. Sandy lias-lime from Vaihingen 0·19; lias limestone from Rohr, near Vaihingen (good hydraulic lime), 1·92; lias limestone from Metzingen 0·93. Lias marl from Kirchheim 0·84; lias slate from Zell, between 13 and 0·19(2). Hydraulic lime from Leube, in Ulm 0·79; hydraulic lime from Blaubeuren 0·74; hydraulic lime from Hall 0·56; blue aluminous limestone from England (blue lias) 0·85; hydraulic lime from Hamburg (Roman cement) between 0·13 and 0·46; Roman cement from England, between 0·30 and 0·45; Portland cement from England, between 0·73 and 0·74.—The presence of phosphoric acid could not be proved with certainty by acetic acid and acetate of soda, but very clearly by molybdate of ammonia. The following limestones gave, often very strongly, the reaction of phosphoric acid. 1. Jura limestone from Unterkochen; 2. Dolomite from Jaxtfeld; 3. Lias lime from Rohr, near Vaihingen; 4. Jura marl from the Geisliger Steige; 5. Keuper limestone from the Weinsteige; 6. Jura limestone from Hundersingen; 7. Amalthean clay from Jesingen, near Kirchheim; 8. Upper Posidonic slate from Ohmden; 9. Aluminous limestone from Blaubeuren; 10. Aluminous muschelkalk from Zoffenhausen. Diluvial limestone of Canstatt, lias marl of Vaihingen, and Carrara marble did not exhibit the reaction of phosphoric acid.

Nicklès(3) examined the coarse limestone of the quarries of Montrouge and Vaugirard, which serves as the common building stone in Paris. To boiling water it yields traces of alkalis, some lime, and organic matter; 100 parts of this lime, dried in the air, contained lime 49·43; carbonic acid 38·79; magnesia 0·02; protoxide of iron 0·91; sand 9·89; phosphoric acid, alumina, alkalis, organic substance and loss 0·96. It also contains faint traces of sulphuric acid, but no chlorine.

Wittstein(4) found that chalk is, like marble and calcspar,

- (1) With traces of chloride of potassium and of sodium.
- (2) Contained sulphate of lime.
- (3) Laur. and Gerh. C. R. 1849, 447.
- (4) Rept. Pharm. [3] III, 150.

anhydrous carbonate of lime, but essentially different from both by its amorphous condition; it contains, besides organic substances which are *always present*, magnesia, alumina, protoxide of iron, sesquioxide of iron, protoxide of manganese, sulphuric acid and phosphoric acid. A white chalk from Champagne dried at 100°, whereby it lost 0·7 per cent in weight, contained in 100 parts: carbonate of lime 97·686; carbonate of magnesia 0·468; silica 1·100; alumina, protoxide of iron, sesquioxide of iron, protoxide of manganese, sulphuric acid and phosphoric acid 0·550; organic matter 0·130; total 99·934. On dissolving the chalk in hydrochloric acid there remained a dark residue which contained, besides organic substances, silica combined with a portion of alumina and sesquioxide of iron.

Wittstein(2), has moreover analysed several varieties of white marble.

	Sp. gr.	CaO, CO <sub>2</sub>	MgO, CO <sub>2</sub>	FeO, Fe <sub>2</sub> O <sub>3</sub> , PO <sub>5</sub>	SiO <sub>3</sub>	Total.
A from Carrara . . .	2·732*	99·236	0·284	0·251	—	99·771
B from Schländers in Tyrol (crystalline)	2·700*	99·010	0·521	0·062	—	99·593
C from the same locality (compact)	2·566*	97·040	2·109	0·360	trace	99·509

\* At 16·25°.

Frickhinger(1) analysed a tertiary fresh-water limestone from the Ries. Where this was deposited on the sandstone of the brown jura, the fine grained siliceous sand of the latter was intimately mixed with the limestone while still soft. After ignition it is entirely soluble in hydrochloric acid. Treated directly with this acid there remain between 26 and 23 per cent of sand. (A) Limestone from Polsingen, (B) from the village of Trendel, a quarter of a league distant from the former.

	SiO <sub>2</sub>	Fe <sub>2</sub> O <sub>3</sub>	PO <sub>5</sub>	CaO, CO <sub>2</sub>	MgO, CO <sub>2</sub>	MnO, Mn <sub>2</sub> O <sub>3</sub>	HO.	Total.
A	33·000	0·848	0·128	65·024	—	traces	1·000	100·00
B	26·625	0·656	—	69·840	1·456	traces	1·432	100·00

**Keuper.**—Völckel(3) has examined a dark gray keuper-stone which occurs on the Balm mountains, near Solothurn, within and by the side of masses of limestone. It contained carbonate of protoxide of iron 33·94; carbonate of magnesia 54·55; carbonate of

(1) Repert. Pharm. [3] III, 24.

(2) Repert. Pharm. [3] II, 30.

(3) From Schriften der Schweizerischen Naturforschenden Gesellschaft, 1848, 43, in Jahrb. Miner. 1849, 701.

Aluminous shale.

lime 0·67; silicate of alumina 8·89; organic substances and water 1·95 per cent.

**Aluminous Shale.**—Pierce(1) has examined in Rammelsberg's laboratory a normal aluminous-shale from the left slope of the Selke valley between Alexisbad and Mägdesprung in the Harz. (A) Portion decomposed by hydrochloric acid=27·3 per cent, (B) portion not acted upon=72·7 per cent, (C) entire aluminous shale.

	SiO <sub>2</sub> .	Al <sub>2</sub> O <sub>3</sub> .	FeO.	MgO.	CaO.	NaO.	KO.	HO.	Total.
A	30·51	23·14	30·98	6·02	1·49	1·31	1·95	3·40	98·80
B	73·47	18·56	2·23	1·91	0·59	3·24*		—	100·00
C	61·74	19·81	10·08	3·03	0·83	1·31	1·95	0·93	100·00†

\* Together with 0·7 coal and loss.

† Together with coal and loss.

**Coal-shale.**—L. Ch. Hess(2) analysed a shale from a coal bed near Bochum, in Westphalia, which was rich in carbon and carbonate of protoxide of iron. He found:

Al <sub>2</sub> O <sub>3</sub> .	Fe <sub>2</sub> O <sub>3</sub> .	FeO.	CaO.	MgO.	SO <sub>3</sub> .	SiO <sub>2</sub> .	CO <sub>2</sub> .	C.	HO.	Total.
6·64	0·94	43·39	0·98	1·16	0·17	1·03	18·67	21·27	4·96	99·21

corresponding to FeO, CO<sub>2</sub>, 60·15 per cent; CaO, CO<sub>2</sub> 1·53, and MgO, CO<sub>2</sub>, 2·40, CaO SO<sub>3</sub> 0·29.

**Bituminous Coal.**—The brown coal of the Hardt near Bonn, which by simple drying in the air turns, by the absorption of oxygen, into pitch-coal(3) loses by this process, according to H. Bleibtreu,(4) 42 per cent of water, and contains, when thoroughly dried, carbon 65·4, hydrogen 5·7, oxygen 26·7 (together with a trace of sulphur), ash 2·2 per cent.

**Fibrous Coal.**—The origination of fibrous coal or mineral charcoal from coniferous wood assumed by Göppert(5) receives confirmation from an observation of A. Daubrée(6) on the miocene bituminous lignites of Lobsann in Alsace, in the fibrous coal of which he recognised the well-known channels of conifers. There is moreover invariably associated with this fibrous coal the resin which originates from conifers, and the yellow-coloured spots on the fibres likewise show the presence of resinous substances.

**Origin of the Bitumen of Bechelbronn and Lobsann.**—In the same place, Daubrée gives a description of the geognostic and technical re-

(1) Rammelsb. Handw. 4. Suppl., 235.

(2) Rammelsb. Handw. 4. Suppl. 119; Pogg. Ann. LXXVI, 113.

(3) See Annual Report for 1847 and 1848, II, p. 505.

(4) Karsten's Arch. XXIII, 413.

(5) See Annual Report for 1847 and 1848, II, p. 504.

(6) Ann. Min. [4] XVI, 287.

lations of the bituminous lime and sandstone of the region of Bechelbronn; from his observations, he draws the conclusion that the bitumen has had its origin as an emanation from the interior of the earth, its production being connected with ruptures of the earth, and indeed in the Alsace with the great elevated fissure of the sandstone of the Vosges, a fissure which was certainly open before the deposit of the trias, but was not yet closed during the tertiary epoch, affording during this latter, moreover, an opportunity for the deposition of spathic iron ore, iron pyrites, and heavy spar. The occurrence of basalt in Gundershofen and the remarkably crystalline structure observed in the limestone of Lobsann, according to Daubrée, are closely connected with these phenomena.

Origin of  
the bitu-  
men of  
Bechel-  
bronn and  
Lobsann.

**Alum-shale.**—According to the opinion of Forchhammer alum-shale was produced by the decay of the various species of fucus and the reduction of the sulphate of potassa present therein, to sulphide of potassium which precipitated the iron in the sea-water in the form of iron pyrites; combining at the same time with the potassa, alumina, and carbonaceous substances, &c. If this idea be correct, we should also find iodine in alum-shale, and in fact Genteles has, as Svanberg(1) states, met with it in the alum-shale of Latorp in Sweden.

**Gold-washings.**—Dufrénoy(2) has given the results of examinations of the gold, of the auriferous earth, and of the goldsand of California, and of comparisons of them with those of New Granada and the Ural. The soil of the valley of the Sacramento is light, and soft to the touch. Its colour is light-brown, and the microscope shows that it consists almost entirely of small angular and transparent pieces of quartz which very easily agglomerate into lumps, and in colour and transparency resemble a saline mass; the naked eye sees only separate grains. From a quartz-boulder it seems demonstrated that the gold lies, in its primitive bed, in veins of quartz, while it results from shaly fragments that these mainly occur in mica slate. The goldsand of California, separated from this by washing, is generally of a dark colour, and we recognise at the first glance the predominance of magnetic iron. The grains have generally a length of 0<sup>m</sup>·00005 and a diameter of 0<sup>m</sup>·00001. The treatment with the magnet by which the iron was separated gave as approximate constituents, magnetic iron 59·82, titaniferous iron (*fer oxydulé titanifère*), iron pyrites with traces of sesquioxide of manganese 16·32; white zircon 9·20, transparent quartz 13·70; corundum 0·67, gold

(1) See p. 170.

(2) Inst. 1849, 281; Ann. Min. [4] XVI, 3; Compt. Rend. XXIX, 193; J. Pr. Chem. XLVIII, 221; Arch. Ph. Nat. XII, 149; Froriep's Berichte aus der Natur- u. Heilkunde 1850, Nr. 39.



Gold-  
washings.

0.29 = 100.00. The perfect crystals of the titaniferous iron and of the zircon seem to show that the mother-rock is not very distant, while the elaboration of both extremities of the crystals indicates that the structure of the rock must be shaly.

The goldsand of New Granada from the valley of the Rio Dolce has still more perfect crystals, and the grains are generally less rounded; it is more gray than black. It consists of the following constituents, the estimation of the proportions being frequently merely conjectural: magnetic iron 34.35; titaniferous iron and iron pyrites 15.00; zircon 20.00; quartz 25.00; corundum 1.00; yellow-gray opaque rock, probably quartz, iron pyrites, and gold 4.65 = 100.00.

In the 'Ural sand the grains are much rounder. This contains magnetic iron 23, titaniferous iron? mengite? and so forth 50, cymophane 10, different kinds of quartz 14, zircon 3 = 100. It contains besides, iron pyrites and copper pyrites.

The goldsand of the Rhine, locality unknown, contained magnetic iron 2 per cent, titaniferous iron from 3 to 4 per cent, quartz 90 per cent (opaque, smoky, dark, topaz-yellow, or rose-tinted, chiefly the latter), also a few crystals of white zircon.

**Coprolites, Rocks, and Earths containing Phosphoric Acid.**—Th. J. Herapath(1) has analysed an earth containing phosphoric acid existing in extensive layers in the lower chalk beds of Sussex and some of the southern counties of England. It formed a bright yellowish-brown coarse powder of 2.981 sp. gr. at 9°. Composition in 100 parts: water 3.400; organic matter traces; silica with some silicate of alumina and silicate of iron 13.240; chloride of sodium traces; sulphate of soda traces; carbonate of lime 28.400; carbonate of magnesia traces; sulphate of lime 0.736; phosphate of lime (tribasic) 21.880, corresponding to 10.098 of phosphoric acid; phosphate of magnesia traces; phosphate of sesquioxide of iron 24.760, corresponding to 11.728 of phosphoric acid; phosphate of manganese traces; phosphate of alumina 6.998, corresponding to 4.789 phosphoric acid; fluoride of calcium traces; loss 0.586 per cent. Total amount of phosphoric acid 26.615 per cent.

Herapath has, moreover, analysed several coprolites from different parts of England(2). 1. Coprolite from the coast of Suffolk, oval, weighing from 600 to 700 grains, sp. gr. from 2.815 to 2.850. It contained in 100 parts: water 4.0, soluble salts traces, carbonate of lime 10.280, carbonate of magnesia and gypsum traces, phosphate of lime (3 CaO, PO<sub>5</sub>) 7.09, phosphate of magnesia traces, phosphate

(1) Chem. Gaz. 1849, 70; Chem. Soc. Qu. J. II, 78 (in abstr.)

(2) Chem. Gaz. 1849, 449.

of sesquioxide of iron 6·9, phosphate of alumina 1·6, fluoride of calcium 0·608, silicic acid 5·792, manganese traces.—2. A similar coprolite, of irregular form and imperfect bony structure. It contained: water 2·6 per cent, combined water and organic matter 9·0, carbonate of lime 39·5, carbonate of magnesia 0·5, phosphate of lime 15·86, phosphate of sesquioxide of iron 9·2, phosphate of alumina 4·71, alumina 6·2, fluoride of calcium 1·7, silicic acid 10·601, soluble salts traces.—3. A coprolite from the lias bed of Lyme Regis, 9 ounces in weight, gray, traces of crystalline structure, softer than the preceding, gave a grayish-white powder. Remains of fish, especially of the *Pholidophorus limbatus*; may be traced. Sp. gr. 2·6 to 2·7. Composition: water 2·6 per cent, water and organic matter driven off by a red heat 3·5, carbonate of lime 23·7, gypsum 1·8, phosphate of lime 60·8, phosphate of sesquioxide of iron 4·1, sesquioxide of iron 2·0, silicic acid 1·6, soluble salts traces.

Coprolites,  
rocks and  
earths  
containing  
phos-  
phoric  
acid.

Various marls, petrifications, and certain amorphous bodies, some of which may be regarded as coprolites, others being phosphoric acid concretions, similar to those of carbonate of lime which are found in clay, &c. in the chalk and green sandstone formations, contain a large proportion of phosphoric acid, and are therefore extensively used in England as manure. The strata in which they lie contain them at least in England through the whole formation, and thus nature presents a source of phosphoric acid, so seldom found in this concentrated state. Even at an early period Henslow had found in the crag and London clay certain nodules thickly spread, which contained from 50 to 60 per cent of phosphate of lime; they were, however, too hard and insoluble to serve as an important article of commerce. J. M. Paine and J. T. Way(1) have made a series of new experiments on those strata in the chalk formation which abound in phosphoric acid. The soft white chalk with flint, forming the upper division of the formation, contains 96·06 per cent of carbonate and 0·26 of phosphate of lime; the second division, the hard white chalk without flint, contains no phosphoric acid. The third division (A), the chalky marl, which is very fertile, contains a greater quantity, but the richest is the upper greensand, and of this, especially its upper thin layer of marl (in depth from a few inches to 10 or 15 feet), which contains in its numberless fossils (B), in its soft, shapeless bodies (C), and even in its marl (D), a large amount of phos-

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(1) Journ. of the Royal Agricult. Soc. of England, IX, part 1; on the same subject see Nesbit in Lond. Geol. Quart. Journ. 1848, IV, 262; Austen, *ibid.* 257; Jahrb. Miner. 1849, 744 (in abstr.) De la Beche's lecture on this subject, Proceed. of the Lond. Geol. Soc. May, 1849, 82; Sil. Am. J. [2] VIII, 422; Froriep's Berichte aus der Natur- u. Heilkunde, 1850, Nr. 77; see also Buckland in Instit. 1850, 15.

Coprolites,  
rocks and  
earths  
containing  
phos-  
phoric  
acid.

phoric acid. The gault also, the second division of the greensand, contains, though more rarely, fossils rich in phosphoric acid (E); the lower greensand, however, is of greatest importance, as at its union with the gault there exists a thick layer of petrifications which contain much phosphate of lime, and which are particularly profitable in a commercial point of view. The soil surrounding the petrifications partakes of the phosphoric acid only so far as it has originated from a decomposition of the latter (F). A fossil conglomerate with sandstone cement from 3 to 18 inches thick, is richer still (G). We also give an analysis of the green grains from the lower green sand formation (H).

	Insoluble sili- cate.	SiO <sub>3</sub> (solu- ble).	PO <sub>3</sub> .	CO <sub>2</sub> .	CaO.	MgO.	Fe <sub>2</sub> O <sup>3</sup> .   Al <sub>2</sub> O <sup>3</sup> .	KO.	NaO.	Water, organ matter hydro- fluoric acid, loss.	SO <sub>3</sub> .	Total.
A	19.64	6.45	1.82	28.98	37.71	0.68	3.04	—	—	—	—	98.32
B(1)	7.68		29.87	8.77	42.29	—	6.87	—	—	4.52	—	100.00
C	7.18	3.28	27.13	8.77	39.85	0.96	10.60	—	—	2.49	—	100.26
D(2)	32.81	29.14	6.61	2.61	9.53	1.97	11.46	3.10	—	3.02	—	99.94
D(3)	26.83	26.30	9.31	2.35	15.24	1.43	13.11	—	—	2.64	—	97.21
D(4)	39.59	18.42	6.89	4.52	9.11	1.64	13.55	—	—	4.12	—	97.84
D(5)	7.12	3.27	33.03	5.58	46.50	trace	1.96	—	—	3.04	—	100.50
E	0.91	—	24.28	12.43	47.46	0.21	2.91   —	—	—	11.80	—	100.00
F(6)	75.46	8.12	0.64	5.64	2.01	0.18	5.59	—	—	2.30	—	99.94
G(7)	43.87	3.25	20.80	1.06*	23.86	0.37	3.35	—	—	3.44	—	100.00
H	18.53		20.65	4.01	34.61	—	7.24   0.98	1.79	1.87	2.28	5.13	97.09

\* CaO, CO<sub>2</sub>.

(1) A branched alcyonite. There is also in it a large amount of amorphous spongi-form bodies, from 8 to 10 pounds weight, containing from 5 to 50 per cent of phosphate of lime, the amount of which increases however from without inwards.

(2) Sifted marl from which the petrifications were separated.

(3) Hardened marl and little fossils which remained on the sieve.\*

(4) Marl from Bentley with the fossils.

(5) The fossils from this marl.

(6) After pounding it and removing the principal petrifications.

(7) The petrifications.

We will also mention here the experiments of Geinitz(1) on the glauconitic sandstone, and the marl of the lower green sand formation of Saxony, which are known to contain potassa, and are often used as manure.

**Morpholite.**—A. Erdmann(1) has made some new experiments upon the morpholites of Sweden known as marlekor, mallrickor and näckebröd. They consist of marl with an amount of carbonate of lime varying from 47 to 49 per cent. The residue is pure clay mixed with more or less of quartz sand. They are all shaly with laminæ of varying thickness and colour. The two protuberances which project from a morpholite are the extreme points of a thick or thin wedge embedded in it. In the interior generally an oval nodule is found. The reniform nodule in the middle contains the largest quantity of carbonate of lime. The layer next to this contains only 51.99 per cent, the outside the least, namely, 44.35 per cent. The lamination goes quite through the outer coating and through the reniform and the wedge-shaped mass, of which the morpholites consist. Erdmann believes that their formation is due in the first place to mechanical forces, which have caused a deposition in parallel strata, but especially also to electro-chemical forces, whereby the molecules became grouped and mixed in an unequal manner.

**Meteorites and Meteoric Dust. Meteoric Iron of Zacatecas.**—Bergemann(2) has submitted to an analysis the meteoric iron of Zacatecas already frequently described(3). The sp. gr. according to three weighings at  $+9^{\circ}=7.4891$ , tolerably accordant with Burkart's and Rumler's statement. The part not soluble in hydrochloric acid amounted to 3.78 per cent, and consisted of a dark brown powdery soft mass, and of a few small shining metallic scales. The former contained iron, nickel, phosphorus and carbon, the latter also iron, nickel and phosphorus, and besides chrome iron. The composition of the meteoric iron as a whole is as follows:

Fe.	Ni	Co.	Cu.	Mg.	C.	C.*	Fe, Ni, P.	Fe, Cr.	S.	Mn.	Total.
85.094	9.895	0.668	0.030	0.187	0.164	0.234	1.649	1.482	0.845	trace	99.348

\* Mixed with iron.

The 1.649 per cent of metallic phosphides consist of 1.103 Fe and Ni and 0.546 P. If we take with Frankenheim the composition of the magnetic iron pyrites as FeS, the meteoric iron consists of nickel-iron 93.77 per cent, magnetic iron 2.27, chrome-iron 1.48, phosphide of nickel and phosphide of iron 1.65, carbon 0.49(4); total 99.66.

(1) Oefversigt af K. Vet. Ak. Förhand. 1849, Nr. 2, 46; Jahrb. Miner. 1850, 34; Fror. Ber. aus d. Natur- u. Heilkunde, 1850, Nr. 81; see Annual Report for 1847 and 1848, II, p. 506.

(2) Pogg. Ann. LXXVIII, 406.

(3) Burkart's Mexico (Stuttgart, 1836), I, 389; Parts'ch, d. Meteoriten, 122; Humboldt's Essai Politique, IV, 107.

(4) Reichenbach, the possessor of the meteoric iron from which borings were taken for this analysis, justly points out (Pogg. Ann. LXXIX, 479) that the analysis of either filings or borings of meteoric iron is likely to give erroneous results, on account of the wear of the instruments. The  $\frac{1}{2}$  per cent of carbon in the meteoric iron of Zacatecas is therefore much doubted by him.

Meteoric  
iron of  
Chester-  
ville.

**Meteoric Iron of Chesterville.**—Ch. U. Shephard(1) examined a large mass of meteoric iron which was turned up by the plough in Chesterville in South Carolina. It was originally of 36 pounds weight, but has been for the most part used for forging. It consists of 5 per cent nickel, traces of chromium, cobalt, and roundish masses of magnetic iron pyrites containing graphite. Besides Wildmanstetten's figures, the polished surface exhibits, by means of the etching process, lines resembling Chinese characters, serpentine markings, &c., which distinguish this from other meteoric irons.

**East Indian Aerolites.**—H. Giraud, in Bombay, describes two meteorites and one mass of meteoric iron from the East-Indies(2).

1. A meteorite from Dharwar fell on the 15th February, 1848; its fall is confirmed by many witnesses. Its collected pieces fitted together formed an oval of about 15 inches in the largest circumference, and 11 inches in the smallest. The stone weighed 4lbs. One of its ends was somewhat flattened. Its whole surface was covered with a dark layer having the appearance of a glaze of  $\frac{1}{8}$  of an inch in thickness; the interior resembled a grayish-white friable sandstone with small metallic glittering specks of the size of a pin's head, which after pulverisation could be separated by a magnet. Its sp. gr. was 3.512. Hydrochloric acid and nitric acid immediately attacked it, and evolved sulphuretted hydrogen while the metallic part was dissolved. An imperfect analysis gave as the composition of this meteoric stone: 58.3 per cent of earthy silicates insoluble in *aqua regia*; 2.5 of sulphur, 6.76 of nickel; 22.18 iron. (Total of these constituents 89.74 per cent).

2. Meteorites from Myhee-Caunta. They fell on the 30th Nov. 1842, in the neighbourhood of the city of Ahmedabad. A piece, forwarded to the geographical society in Bombay, possessed all the characters of the *aérolite* of Dharwar. Its sp. gr. was 3.360. No analysis of it has been given.

3. Meteoric iron from Singhur, near Pouna in the Deccan. The mass was found by labourers on a basaltic mountain 4500 feet above the sea, near Fort Singhur, and sent to Bombay. It had the shape of an irregular three-sided prism, and was conical at the ends. It was 12½ inches long, and in its thickest part from 5 to 5½ inches thick. It weighed 31lbs. 4oz. The sp. gr. varied in different pieces from 4.72 to 4.90. It was very full of cavities near the outside and cellular within, and contained small whitish-yellow earthy particles of the size of a pea. There were found in it earthy silicates 19.5, iron 69.16, nickel 4.24. (Total of these constituents 92.93.)

(1) Sill. Am. J. [2] VII, 449; Froriep's Berichte aus d. Natur- und Heilk., 1850, Nr. 77.

(2) Edinb. New Phil. J. XLVII, 53; Instit. 1849, 319; Froriep's Notizen aus d. Natur- u. Heilk. XI, 254.

**Meteoric Dust.**—Ehrenberg(1) examined a black inky rain-water which fell in Ireland on the 14th April, 1849, over an area of 700 square miles. The microscopical analysis of this water showed that the black colour was caused neither by the dust of volcanic ashes nor by soot, but by minute particles of decayed plants, which were mixed with infusorial forms of plants and animals. Ehrenberg thinks that this black rain is due to dust carried over by the trade winds, which being long driven about with clouds of aqueous vapour has become decomposed and decayed.

Meteoric  
dust.

(1) Berl. Acad. Ber. 1849, 200.



**SYMBOLS AND EQUIVALENTS ADOPTED IN THE ANNUAL REPORT.**

Aluminum	Al = 13.7	Nickel	Ni = 29.6
Antimony	Sb = 129	Niobium	Nb =
Arsenic	As = 75	Nitrogen	N = 14
Barium	Ba = 68.5	Norium	No =
Beryllium	Be = 4.7	Osmium	Os = 99.6
Bismuth	Bi = 213	Oxygen	O = 8
Boron	B = 10.9	Palladium	Pd = 53.3—
Bromine	Br = 80	Pelopium	Pe =
Cadmium	Cd = 56	Phosphorus	P = 32
Calcium	Ca = 20	Platinum	Pt = 98.7
Carbon	C = 6	Potassium	K = 39.2
Cerium	Ce = 47	Rhodium	R = 52.2
Chlorine	Cl = 35.5	Ruthenium	Ru = 52.2
Chromium	Cr = 26.7	Selenium	Se = 39.5—
Cobalt	Co = 29.5	Silicium	Si = 21.3
Copper	Cu = 31.7	Silver	Ag = 108.1
Didymium	D = 50	Sodium	Na = 23
Erbium	E =	Strontium	Sr = 43.8
Fluorine	Fl = 19	Sulphur	S = 16
Gold	Au = 197	Tantalum	Ta = 184
Hydrogen	H = 1	Tellurium	Te = 64.2
Iodine	I = 127.1	Terbium	Tb =
Iridium	Ir = 99	Thorium	Th = 59.6
Iron	Fe = 28	Tin	Sn = 58
Lanthanium	La = 47	Titanium	Ti = 25
Lead	Pb = 103.7	Tungsten	W = 95
Lithium	Li = 6.5	Uranium	U = 60
Magnesium	Mg = 12.2	Vanadium	V = 68.6
Manganese	Mn = 27.6	Yttrium	Y =
Mercury	Hg = 100	Zinc	Zn = 32.6
Molybdenum	Mo = 46	Zirconium	Zr = 22.4

N.B.—THE ATOMIC WEIGHTS AND EQUIVALENTS ARE ASSUMED TO BE EQUAL.



## Abbreviations in the References.

The numbers in [brackets] indicate that the volume quoted belongs to a series (*série, Folge*) represented by such numbers.

Ann. Ch. Pharm.	sign.:	Annalen der Chemie und Pharmacie, herausgegeben von Wöhler und Liebig.—Heidelberg.
Ann. Ch. Phys.	"	Annales de chimie et de physique, par Gay-Lussac, Arago, Chevreul, Dumas, Pelouze, Boussingault et Regnault.—Paris.
Ann. Min.	"	Annales des mines, rédigées par les ingénieurs des mines.—Paris.
Arch. Pharm.	"	Archive der Pharmacie, herausgegeben von Wackenroder und Bley.—Hanover.
Arch. Ph. Nat.	"	Archives des sciences physiques et naturelles, par de la Rive, Marignac, Pictet, de Cándolle, Gautier, Plantamour et Favre.—Genève.
Berl. Acad. Ber.	"	Monatsberichte der Academie der Wissenschaften zu Berlin.
Bull. Géol.	"	Bulletin de la société géologique de France.—Paris.
Chem. Gaz.	"	Chemical Gazette, conducted by Francis.—London.
Chem. Soc. Mem.	"	Memoirs and Proceedings of the Chemical Society of London.—London.
Chem. Soc. Qu. J.	"	The Quarterly Journal of the Chemical Society of London.—London.
Compt. Rend.	"	Comptes rendus hebdomadaires des séances de l'académie des sciences.—Paris.
Ding. Pol. J.	"	Polytechnisches Journal, herausgegeben von G. J. Dingler und E. M. Dingler.—Stuttgart.
Jahrb. Miner.	"	Neues Jahrbuch für Mineralogie, Geognosie, Geologie und Petrefactenkunde, herausgegeben von Leonhard und Bronn.—Stuttgart.
Jahrb. Pr. Pharm.	"	Jahrbuch für practische Pharmacie, redigirt von Hoffmann, Winckler und Zeller.—Landau.
Instit.	"	L'Institut; section des sciences mathématiques, physiques et naturelles, dirigé par Arnould.—Paris.
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# ABBREVIATIONS IN THE INDEX.

Act. . . . .	Action.
Anal. . . . .	Analysis.
Appl. . . . .	Application.
Boil. p. . . . .	Boiling-point.
Comb. . . . .	Combination.
Comp. . . . .	Compare.
Compos. . . . .	Composition.
Cond. r. . . . .	Conduction-resistance.
Const. . . . .	Constitution.
Cryst. f. . . . .	Crystalline form.
Decomp. . . . .	Decomposition.
Deport. . . . .	Department.
Determ. . . . .	Determination.
Detect. . . . .	Detection.
Electr. . . . .	Electricity.
Equiv. . . . .	Equivalent.
Exp. . . . .	Expansion.
Exam. . . . .	Examination.
Form. . . . .	Formation.
Fus. h. . . . .	Fusion-heat.
Fus. p. . . . .	Fusing-point.
Invest. . . . .	Investigation.
Lat. fus. h. . . . .	Latent fusion-heat.
Lat. h. . . . .	Latent heat.
Lat. vap. h. . . . .	Latent vapour-heat.
Occur. . . . .	Occurrence.
Opt. deport. . . . .	Optical department.
Org. subst. . . . .	Organic substance.
Precip. . . . .	Precipitation.
Prod. . . . .	Product.
Prep. . . . .	Preparation.
Prop. . . . .	Properties.
Recogn. . . . .	Recognition.
Separ. . . . .	Separation.
Solut. . . . .	Solution.
Sol. . . . .	Soluble.
Spec. grav. . . . .	Specific gravity.
Spec. h. . . . .	Specific heat.
Subst. . . . .	Substance.
Temp. . . . .	Temperature.
Tens. of vap. . . . .	Tension of vapour.

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